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THE SCIENTIFIC STUDY OF THE CURRICULUM.

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Several printed statements now present excellent discussions of the steps involved and limitations placed upon the scientific method, as a form of thinking and working. It is not my purpose at this time to give another analysis of this method, but to discuss a few of the interpretations and uses of scientific method as applied to curriculum revision. I wish to speak of the following questions: The common uses made by educators of the terms research and scientific method; some essential notions regarding accuracy and the progressive nature of truth; the cumulative nature of truth in the natural sciences and in other fields; some illustrations of fundamental studies in the curriculum; and the problem of training investigators for curricular research.

The extent to which the word "scientific" is now used clearly indicates that people generally believe in some sort of gain through a relationship with science. The words "research" and "investigation" have become commonly used by persons who desire to imply a growth in the fundamental nature of what they are doing. I have seen a workman's shop sign which announced him as "Scientific shoer of horses"; also a placard which read "Scientific undertaker, work done expeditiously, effectively and without disturbance." An artist who was being considered as painter of a classroom picture which was desired to illustrate a school room of his native country, asked if the suggested fee covered both the painting and what he called the preliminary library research required to determine which objects and situations should be shown in the classroom

picture. The artist later asked for the appointment of an assistant who would, as he said, do his "research work" for him. A teacher of a second grade group of pupils informed me that her seven-year old pupils had gone to the library "on a piece of research work." They had, in fact, been sent to read simple stories regarding various methods of transportation which were to be the basis of a class discussion. The head of a university department of moral and religious education, who had announced graduate courses in research, asked for assistance in the form of a list of problems for the proposed researches by his students. He asked that each problem should be accompanied by an outline of the methods to be pursued, the source materials to be used, the experimental work recommended, and the probable outcomes and uses that each suggested piece of research might have when finished. The professor stated that he himself would locate, assign and guide the students in these researches.

As a teaching proposition, modern education has been keen that accumulated knowledge shall be approached by learners who sense the real problems to be solved. Learners must have questions or problems whose answers they seek to find. The development of the problem attitude in education is generally regarded as one of the best contributions of recent teaching methods. The point now raised relates, however, to a distinction between proper methods of teaching or learning, as compared to the real meaning of the kind of research which is designed to add to what is known regarding a curricular topic. For the learner, the use of problems is like research, since it adds to his store from what is now known and recorded, and does so by training him in meeting problems. But the purpose and result of his studies were not to add materially to what is recorded as known of the topic, hence it is improper to call it research. A false or stilted use of terms does not change the nature of the work done.

The above comments indicate that the appeal of scientific method in education has been sensed more readily than have its obligations and requirements. This is not illogical nor especially disturbing if the situation is appreciated and proper correctives applied. It is not new to have the devotees of education over-sell their production departments. The publicly energetic life of a successful salesman seems to appeal to more people than does the more prosaic and obscure life of the

intensively engaged laboratory worker. And when the same worker tries to operate in both capacities, one function sometimes tends to inhibit the other. Many helpful educational improvements have become sloganized and exploited, and claimed to produce improvements not likely to be secured. As example, note the history of movements which became the basis of such slogans as "freedom" in childhood; "apperception"; "correlation"; "motivation"; "standardization"; the "interest theory"; the "project method"; the "creative element" in education. These successive movements have many common elements. Thoughtful students see great gain in each of these movements.

The scientific movement cannot be expected suddenly to produce a tested and proved curriculum It cannot be expected that most educationists will soon become scientific. It may even be questioned whether any considerable proportion of people generally will expend the effort necessary to a logical organization and adequate testing of fundamental ideas. Do not most prefer to be told what and how to do? It is too much to expect any large proportion of even well-educated people suddenly to depend upon objective evidence rather than on the authority with which they chance to be familiar. This fact, that most educationists expect and must have careful guidance adds an extremely important element to the curricular problem. The curriculum as presented to most teachers is their accepted guide, hence the importance of assuring real improvement in any changes that are made; and as a corollary, the danger of hasty and inadequate recognition of the possibilities and limitations of sound improvement of the curriculum.

What is scientific accuracy? It is usually relative, not final. Whether applied to facts, to processes, to underlying principles, or to induced and deduced conclusions, we can in but few cases expect final and complete accuracy. In the most dependable studies in the more nearly exact sciences such as physics and chemistry, most of what is known is incomplete, because some of the factors are unknown or imperfectly known. What is now stated as known must later be adjusted as the related factors become known. In all true progress in the sciences, effort is constantly directed toward determination of the previously unknown, the uncontrolled, and the varying factors.

There sometimes is the impression that scientific achievement is solely or largely the work of the person whose name is

currently associated with it. Such an interpretation is true in but a small number of cases. Usually any really important piece of work has come to its present condition through and because of a progressive series of studies, which have slowly approached accuracy. Thus Marconi who was widely credited as discoverer of the foundations of wireless telegraphy is now known to have built a few steps upon a ladder which he found fairly well constructed, and upon which students following Marconi have built many added steps. Millikan's achievements are not reduced but magnified, by our knowing that certain students in Germany, and eminent scientists in England had brought the world's knowledge of structure of matter well along toward the point where it now is; and that each year, almost each month, added researches by any one of a dozen workers are now clarifying and reforming existing notions of matter and electricity. In education, where the achievements are as yet smaller than in the exact sciences, but by no means unimportant, those persons who are sometimes credited with having discovered new bases for organizing a subject of study have found and have used definite tendencies and definite subject materials and methods. They have formulated them anew and tested them by as good means as they could command. Others have then followed with new studies. None of these subject organizations can be regarded as having reached a condition in which it will long remain.

Truth is progressive. Scientific studies utilize long series of preceding studies, add a measure of new evidence and consequent accuracy, and frankly accept and cite the unknown and variable elements which, when determined, will probably change the thought and conclusions as they now appear.

Also, in any of the more exact sciences, progress is made by the accumulation of exact studies upon relatively small portions of the whole subject. Thus, in order to ascertain the rates and periodicity of plant growth one group of students studies the rate and nature of growth of the root tips of one small group of plants. Another group studies the growth and behavior of roots in desert soils, in swamps, and in well-watered and drained soils. Another gives years of study to the growth of roots in moist atmosphere with and without light. Another group has been engaged for more than a decade in determining the amount, rate and periods of thickening of forest trees. Groups of workers in almost all laboratories in all leading

countries are engaged in some aspect of the physical, chemical and biological changes which occur within green leaves as the food materials for plant growth are being transformed. These and many other workers engaged upon small parts of the whole subject are fully aware that their accumulated efforts when added to those of preceding generations of research, will need supplementing by later specific and intensive studies.

I have already referred to recent discoveries relative to the electronic aspects of matter. A closely related topic provides added assistance in the proper application of scientific method to curricular studies. When radium was discovered and introduced to a startled public, the nature of its behavior and uses were imperfectly known. This condition still exists in part, but the wide use of radium and the world-wide search for new supplies are matters of common knowledge. The entire world's accumulated supply of radium weighs about one pound. Its action as now understood is due to certain rays, known as Beta rays, which emanate from the radium. These Beta rays are made up of electrons which fly from the radium. Lack of knowledge of the action or behavior of these Beta rays has caused numerous serious injuries to persons experimenting with them, or upon whom experiments with radium have been made. It is perhaps fortunate that the available supply of radium has been low enough to restrict experimentation with it. A little radium, like a little science, may be "a dangerous thing."

But now comes Dr. W. D. Coolidge of the General Electric laboratories with an astonishing device for producing and controlling Beta rays. By means of a cathode ray tube of very special construction he has been able to control electronic action so as to produce Beta rays estimated at two thousand times those that would be produced by the world's total collected supply of radium. This means that the Coolidge cathode ray tube when under the influence of the electric current which passes through it, would, in its possible effect, be compared, not to the pound of radium now possessed by the whole human race, but to one ton of radium, which is 1999 pounds more than all the radium now possessed. This new device has enabled its inventor to learn new facts about the rate of movement of the electrons. When they are first thrown off from the tungsten filament within the tube they are moving at a rate of about one or two miles per second. Under the

influence of the heavy charge of electricity, which is somewhere near 350,000 volts as used, the electrons acquire a speed of approximately 150,000 miles per second. This speed has been gained by the time the electrons pass out of the window of the cathode ray tube. The distance through which this astounding increase of speed occurs, from one or two miles to 150,000 miles, is about one inch.

What are the effects of the Beta rays from the Coolidge cathode ray tube? Not much is known as yet. An exposure of 1-10 of a second to the ear of a rabbit caused the skin and hair to die but later the skin healed and a new growth of longer hair of different color appeared. A slightly longer exposure killed the tissue affected. Flies and bacteria were killed by an almost instantaneous exposure. A flippant person might at once see possibilities in hair production, or in freedom from flies and bacteria; but difficulties remain in getting the flies and bacteria properly herded for treatment, and in making sure that hair production would not come at the sacrifice of everything else. The uses of this new discovery are almost wholly left for further investigations. More recent announcements not yet in print indicate that a newer device may give controls of electronic action not possible by use of the first announced cathode ray tube.

The comparative applications of this study to the uses of scientific method in curricular work are found in the following fact. Dr. Coolidge's work is built upon preceding studies. Those studies which were relatively exact, had produced some accurate knowledge and had made some unknowns more evident. Dr. Coolidge's attention was not upon the whole problem of structure of matter, not even upon electrons and protons as a whole problem, but seems to have been focused upon the production, control and further study of Beta rays, similar to those appearing from radium. Persons competent to judge might even say that Dr. Coolidge's work consists chiefly in a new and ingenious combination and use of work previously accomplished by others. In adding some knowledge, new problems have been raised, whose further study is imperative. Research produces finality only in that it adds a few solid building stones for further construction. The building itself is always being remodeled, and the family of ideas living in the building never really gets settled.

Education is new as an exact study. Our best progress in

exactitude so far has come not in studies of subjects, subject contents, or methods of handling subjects, but in measurement of skills resulting from the use of subjects. By inferences and by comparisons something has been learned by back-tracking, so to speak, from measured skills to the types of subject contents and organization from which the measured skills seem to have come. For example in reading, the skills have been tested in such ways as to show, to some extent, what types of content and of practice in reading produce certain types or results. Such studies as those by Gray, Judd, Buswell, Gates and many others form an indirect and very helpful contribution to curricular study. The next big advance in education is generally expected from a more direct study of curriculum materials themselves. This expectancy is indicated in part by the hosts of invaders into the curricular territory. Amidst all the confusing mass of print, a few outstanding studies are hopeful as showing the technique and care so necessary to foundational work. It must be noted also that the pieces of work which we may cite are from workers who are not known as our most prolific educational writers. Quantity production of goods of high quality usually is impossible until sound research has standardized the materials and processes.

Of the several pieces of work available, I shall cite illustrations which may be given briefly. Others might be cited which would be quite as good for our purposes.

Leonard P. Ayers initiated the study of spelling by finding what words children use. In an earlier day, the lists of words that were used as the basis of spelling lessons by children were made up without much reference to the working vocabularies which children employ. Horn and Ashbaugh collected word lists from a very large number of children's responses, both verbal and written. In this way they were able to accumulate lists of the words in use in a very wide range of children's experiences. Then they formulated spelling tests by means of which to find out which of the words make difficulty in spelling. Having done this, they could be sure that they were recommending spelling lists which deal with the types of words which children really need to learn to spell. Possibly we need other studies to find words not now used which children should use and should learn to spell. Associated with this work of Horn and Ashbaugh was their study of methods of teaching spelling in which equally sound contributions have been made.

The facts of this study and the quality of its accuracy is such that practically no recent effort in the field of spelling fails to include the findings of Ayers, Horn and Ashbaugh.

Dr. Henry Harap's Study in Curriculum Material as found in his "The Education of the Consumer," provides a different kind of illustration (p. 4). "It is the purpose of this study to discover the objectives of education for American economic life with special reference to the consumption of food, shelter, fuel and clothing. The conclusions of this inquiry are termed educational objectives because they are habits, skills, knowledge, or attitudes which should be achieved by educational activity." In attempting to discover valid educational objectives and the consequent subject contents involved, Dr. Harap first accumulated a large amount of factual and statistical data relating to the economic habits of the American people. He utilized the reports of various governmental departments, studies of private workers, and of many organizations. His aim was to gather such evidence as he could find descriptive of the habits or practices of our people in the consumption of goods. In contrast with these data, and as an important additional problem he collected all available standards which have been suggested and supported by facts as representing desirable standards of consumption. These standards have been worked out by many individual research workers, by government agencies, and by other organizations. By comparing the actual practices of Americans with the best available standards in other countries Dr. Harap was able to develop specific changes which it would seem should be brought about in food consumption. These desirable changes were included in the educational objectives.

Dr. Harap's aim was to discover in an exact way what factors affect human life most vitally as concerns the materials of food, clothing, shelter and fuel. To quote (p. 11): "The method, as used in this study, to determine objectives of the curriculum belongs to that class of studies which uses quantitative data describing actual life conditions in order to determine what shall be learned in school." It is to be noted that this method accumulates and organizes quantitative data setting forth actual needs, but more than that it sets forth these needs, in part, from standards of the best uses consumers may make, and in part from those which may improve the uses of food, shelter, fuel and clothing.

There are many illustrations in this study of exact founda-

tions upon which his conclusions are based. For example, the author reaches conclusions about training for selection, purchase and use of meats by finding what and how much meats are used. By using existing statistical reports he constructs the following table of meat consumption in different countries.

PER CAPITA CONSUMPTION OF MEAT IN EUROPE AND AMERICA.

Country	*Per Capita in Pounds*
Italy	23
Russia	59
Austria-Hungary	64
France	74
Belgium, Holland	75
England	105
Germany	115
United States	187

Then he discovers that in the United States 96.6% of all the meat consumed is pork and beef. He then finds that in food budgets for workingmen's families not less than one-fourth of the expenditure was for meat, and usually the meat item approaches one-third the total food bill. The U. S. Bureau of Labor Statistics reports 2,567 families of whose total food costs 31.4 per cent was for meat.

Dr. Harap, by means of many studies such as those cited, formulates the following objectives for curricular work which deals with meats.

EDUCATIONAL OBJECTIVES CONCERNED WITH THE CONSUMPTION OF MEAT

To become aware of the unusually excessive per capita consumption of meat in the United States.

To know the function of pork, beef, mutton, lamb, and veal in the diet.

To know that pork is especially rich in fats.

To identify the chief cuts of beef, veal, mutton, lamb, and pork and to know their most appropriate uses.

To know the relative food value of the various cuts of beef, veal, mutton, lamb, and pork.

To cultivate the habit of buying the most economical cuts.

To know that the function of meat in the diet can be served by meat substitutes.
To spend less money on meat.
To cultivate the habit of buying less meat.
To know that meat is the most expensive protein food.
To know in terms of weight just how much meat is sufficient for each member of the family.
To use milk, eggs, beans, peas, cheese, nuts, and fish instead of meat.
To consume more fish.
To know the relative value of meat and fish as protein foods.
To know that the total food bill increases as the expenditure for meat increases.
To know that the greater the expenditure for meat in the diet, the less is the total nutritive value received.

It is not claimed that this study does anything for the curriculum in arithmetic, spelling, reading, penmanship, science or history, although a correlationist at once sees collateral uses of the results of the study. It does not pretend to illuminate or illustrate the "project method" or "purposeful unit of work." It does build a foundation in exact knowledge, and suggests a part of the knowledge still needed. The whole report of 360 pages speaks clearly and factually of the study of the real foundations of curriculum making.

But a geographer, historian, teacher of civics and economics, or a school administrator or supervisor might possibly be disappointed because Dr. Harap's study does not end in a new course of study; possibly any one of the above teachers might be disturbed because the study seems to omit important subject elements or possibly may include seemingly unimportant topics. Such anxiety is beside the major issue. The purpose is to determine and organize the truths of the situation in hand, and to set these forth as partial guides for further curricular organization. The task is bigger than most educationists appreciate. It is clear that such studies involve tremendous labor if we are to define objectives based upon real knowledge. Also that the procedures by means of which to give instruction so as to attain these objectives, involve even more extended and intensive studies. But nothing less will produce curricular materials and methods which meet our present standards of research. Accumulated researches of the types cited will slowly produce fundamental curricular changes.

A difficulty pertains to training of research workers in the curriculum. As yet the work has been too largely by graduate students who have done a single piece of work, that piece usually having undergone many trials before being accepted as the purchase price of a graduate degree. Graduate work too often is not primarily a search for new truth, but a device for acquiring a degree or title which in later years is not supported by productive scholarship. Graduate courses are often mere extensions of undergraduate instruction. In education we possess few illustrations comparable to the research divisions of the sciences and industries. Such institutions require trained workers who continue in research.

At present the popularity of curricular research is one of its chief dangers. When an experimental school was announced ten years ago, to work upon the improvement of the subjects of study, query was frequently raised whether there was a place for such an institution. Some radical persons asserted that we already knew what changes in subjects were needed; while educational fundamentalists asserted that the proposed program of work was designed to disrupt and destroy all that is good of conventional practice; indeed the more frightened fundamentalists asserted that curriculum study was being set up with the motive of indoctrinating an oncoming generation so that they might serve the ulterior and ignoble desires of unholy vested interests. The radicals were wrong, since it is such a long way from seeing a possibly good chance to the point of getting it actually developed, and proved or discarded by practice. The fundamentalists were wrong since no group of workers worthy of the privilege of cooperation in such a task could fail to see how very little one such group could accomplish toward actual scientific improvement. However, curricular research soon gained attention and acquired popularity. At the Cleveland meeting of the Department of Superintendence the Executive Committee presented a half-day's program dealing with curricular studies. That organization has constantly engaged in curricular work since that meeting, their work being mainly of the committee type, these committees calling upon individuals to contribute from their own investigations. Also whole school systems have organized themselves for curricular study, each teacher of the system being assigned to one or more committees. As yet the actual amount of new curricular material, new organization, or ex-

perimental evidence from these sources is not large. This by no means indicates that the endeavor has been unprofitable. It is questionable, however, whether a teaching staff sometimes may be misled into thinking it has reorganized its curriculum when it really has made its gain through a restudy of the content and purpose of its subjects of study. We should be clear that such a service is essentially training of teaching staff, rather than curricular research.

Educational research is perhaps most difficult of all. In pure mathematics, physics and chemistry the nature of the subjects permits a relatively high degree of accuracy of work. In biology the variations introduced by life produce complications not found in the so-called more exact sciences. And when we consider economics, education or any other social subject into which are inserted not only life in many manifestations, but human aspirations, affections, hates and ambitions, we find complications which up to date have proved baffling to the spirit of scientific study. But whether science can truly study the education of the children of those who are the agents by whom truth is discovered, and by whom knowledge is organized, is the most compelling and most challenging test of science.

ANNUAL EDUCATIONAL CONFERENCE.

The Seventh Annual Educational Conference sponsored by the Ohio State University will be held at that institution on April 7, 8 and 9, 1927. As in former years the general sessions will be held on Thursday evening, Friday evening and Saturday morning. Men of national note, such as Professor E. L. Thorndike of Teachers College, Columbia University, Professor Wallace W. Atwood of Clark University, Judge Olson of the Juvenile Court of Chicago, Payson Smith, Commissioner of Education for Massachusetts, and others will address the general sessions.

Both forenoon and afternoon of Friday will be given over to sectional meetings of which this year there will be more than thirty. Here again specialists in their fields will contribute as, for example, Professor S. A. Courtis of Michigan in the Educational and Intelligence Test Section; Professor S. A. Leonard of Wisconsin in English; Professor Hill of Illinois in Non-biological Science, etc.

The keynote of this year's conference is "Expertness in Teaching" and the whole program, both general and sectional, will center around this idea. The uniform testimony of the thousands who have attended past conferences is that each year the conference is outstanding for its helpfulness, its abundance of ideas and its lack of mere talk. There is every reason to believe that this year's program equals, if it does not exceed, all former ones.

THE CELEBRATED CASE OF ANALYTIC AND INDUCTIVE METHOD VS. SYNTHETIC AND DEDUCTIVE— ARGUMENT FOR THE PLAINTIFFS.

By J. O. HASSLER,

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Gentlemen of the Jury (of Teachers):

In making this plea for my clients, Analytic Method and Inductive Method, I do not desire in any way to impugn the character or reputation of the defendants, Synthetic Method, and Deductive Method, who are indeed cousins of the plaintiffs. I shall not ask the death penalty but I do insist that they be enjoined from trespassing so much in the domain of the teaching of elementary geometry as has been their custom in the past. Let us consider first the relations between Synthetic and Analytic Method.

Two couriers desire to cross a wide area under the eyes of sharpshooters in order to reach a desired goal on the other side. The first selects a cover a short distance away and creeps to it. Reconnoitering under its protection, he selects another further on and creeps to it. Pursuing this policy, he continues and, if his sense of direction is good, will arrive at his destination in due time. At each point of his progress he was sure of no more than one successful step ahead. The second courier surveys the goal with his field-glasses. He sees a short distance back from it a shelter from which, if he could reach it, he might complete the journey. Back from this he "spots" another form which he could reach the first unseen. Continuing in the selection of a possible route (in reverse direction) he finally selects a cover that he can reach from where he stands. His course is mapped out. He is ready to begin his journey with certainty of success, knowing the location of every stopping place on the way. The first courier's progress is analogous to that of Synthetic Method, the second to Analytic.

Synthetic Method proceeds by logical steps from a hypothesis to a conclusion, from the known to the unknown. No clue is given as to the reason why each step is made; it is only made. It is the method of presentation of finished logical proof as exemplified by the usual proofs of the propositions in geometry.

Analytic Method proceeds from the desired conclusion, step by step, until contact is made with the hypothesis, that is, reasoning from the unknown to the known. Before being selected each step is tested and approved as to its possibility of being

a link in the chain of proof. This is the method of discovery of a new proof.

As an illustration consider a familiar theorem which, though properly belonging to algebra, is always proved in geometry.

If four numbers are in proportion they are in proportion by addition (composition).

Given: $\frac{a}{b}=\frac{c}{d}$.

To prove: $\frac{a+b}{b}=\frac{c+d}{d}$.

Synthetic proof: (The reasons for the steps are omitted.)

$$\frac{a}{b}+1=\frac{c}{d}+1.$$

$$\frac{a+b}{b}=\frac{c+d}{d}.$$

Analytic proof:

If $\frac{a+b}{b}=\frac{c+d}{d}$, then $\frac{a}{b}+1=\frac{c}{d}+1$;

and if $\frac{a}{b}+1=\frac{c}{d}+1$, then $\frac{a}{b}=\frac{c}{d}$.

which is given as the hypothesis. Now by reversing the steps in the analysis we obtain the synthetic proof.

In the synthetic proof the addition of 1 to both sides of the equation is like a step in the dark to one who has not previously analyzed the theorem. In some longer proofs there are many steps to be taken by the student the reason for which he can not see.

To give Synthetic Method unhampered freedom is to promote the bad habit that is generally recognized and unanimously opposed by good teachers; namely, the habit of memorizing proofs. It taxes the ingenuity of the very best of teachers to make all the steps in the usual synthetic proofs seem so reasonable to the pupil that he might be expected to reproduce them by a course of independent thought rather than by remembering what comes next.

An appeal to Analytic Method will be of great value to the teacher. The pupils who become well acquainted with Analytic Method will grow in reasoning power and will find that they can understand more readily the subject matter of geometry.

Shall we then completely ostracize Synthetic Method? I do not ask such an extreme penalty. He teaches a clear, simple,

concise manner of recording proof and pupils should learn that very valuable thing.

We shall next consider the relations between Inductive Method and Deductive Method.

Inductive Method assumes a general truth as the result of having observed its verification in many particular cases. In this case the procedure is from the particular to the general in contrast with the procedure from the general to the particular as made by Deductive Method. Inductive Method does not prove; he discovers. He finds the material for Deductive Method to prove. Mendel's Law of inheritance, Boyle's Law for gases, and empirical formulas of practical mathematics were all discovered by Inductive Method. Let us consider two illustrations from mathematics, one where the Inductive Method has no place and one where he may control the teaching.

Suppose we are teaching the theorem in plane geometry about the sum of the interior angles of a triangle. The pupils may measure the angles in many triangles and average the sums, but it in no wise establishes the fact that the sum is actually 180°. The exercise bears no relation whatever to the proof that we are about to make of the theorem.*

Suppose instead that the theorem about the sum of the angles of the triangle has been established. The pupil is encouraged to investigate the sums of the interior angles of other convex polygons, the quadrilateral, the pentagon, etc. He divides each of them into triangles by means of diagonals drawn from the vertex of one angle. A tabulation of his observations would yield the following facts:

Number of sides of the polygon	3	4	5	6	7	8
Number of △s into which it is divided	1	2	3	4	5	6
Sum of the ∠s (expressed in rt. ∠s)	2	4	6	8	10	12

A study of this table reveals the fact that the number of triangles (as far as he has observed) is always two less than the number of sides and the sum of the interior angles is twice as many right angles as the number of triangles. If the poly-

*This exercise would not necessarily be taboo in the intuitional geometry of the seventh and eighth grades. We do not claim that there may not be inductive methods applied to this theorem which will be illuminating, but this particular one in this place (formal geometry) is not good.

gon has n sides this would mean that the sum of the interior angles is $2(n-2)$ right angles. No amount of trial can ever establish this as a truth satisfactory to mathematics for we can never try all possible cases. Inductive Method has suggested, however, a method of proof while suggesting the possible truth itself. Using this method, we establish the general formula: sum $=2(n-2)$ rt. $\angle$s.

We find Inductive Method controlling the teaching in practically all texts in algebra by a series of exercises much like the following:

$x+3$	$x-3$	$x-3$	$x+3$
$x+5$	$x+5$	$x-5$	$x-5$
x^2+3x	x^2-3x	x^2-3x	x^2+3x
$\quad 5x+15$	$\quad 5x-15$	$\quad -5x+15$	$\quad -5x-15$
$x^2+8x+15$	$x^2+2x-15$	$x^2-8x+15$	$x^2-2x-15$

In each case attention is called to the fact that the coefficient of the common term x in the product is the algebraic sum of the two constant terms of the factors and the constant term in the product is the product of the two constant terms in the factors. This leads us to surmise the general formula and prepares our minds for its form; namely, $(x+a)\ (x+b)=x^2+(a+b)x+ab$, which we proceed to establish. The use of induction brings a pupil gradually to the general formula which if given at the outset would be hard to understand.

When we have established the general formula, we infer by deduction that if we multiply $(x-4)\ (x+6)$ we will obtain $x^2+2x-24$ and need not take the time to multiply.

Let us now cease the lame attempt at personification and make the conclusion.

The use of the analytic and inductive methods in teaching mathematics will serve the great purpose of developing a spirit of inquiry (some may want to call it research) in the student. His ingenuity must be drawn upon and habits of independence and originality of thought will be the result. Induction leads him through particular situations, concrete to him, to an appreciation of a general truth whose very generality if placed before him at the beginning would probably place it beyond his comprehension.

The synthetic and deductive methods serve also the aims of education. Nowhere in the whole scale of learning processes and nowhere in the whole list of high school subjects is there such excellent opportunity to learn simple, accurate, concise and powerful modes of expression as in the statement of a synthetic, deductive proof. The synthetic and deductive methods should follow the analytic and inductive methods. If the synthetic and deductive methods come first the process of learning will probably degenerate into a memorizing process.

Let us, by a judicious use of the inductive and analytic methods, inspire in our pupils the spirit of the intellectual pioneers of the past who, by force of their ingenuity, resourcefulness, and originality, pushed out into the intellectual unknown to find the truths that awaited them there.

SALMON RIVER, IDAHO, HAS LARGE POWER RESOURCES.

On a motor trip along the Salmon River highway that parallels Salmon River for 125 miles between Salmon City and Stanley, two impressions may strike the traveler. The first will probably relate to the geology and physiography of the valley as revealed by the rugged, multi-colored canyons with intervening benches of irrigated land and barren waste. The second impression will be that of the seemingly endless possibilities for developing water power. In several publications the Geological Survey of the Department of the Interior has discussed the geology and mineral deposits of the region through which the Salmon River flows, but no information has yet been made available with reference to its power resources.

During 1912 some preliminary work was done by Engineers of the Geological Survey with a view of determining to what extent the use of the valley for a railroad right of way would interfere with the future development of water power, and at different times during 1916, 1919, and 1924 surveys of the river and of possible dam and reservoir sites were made. The results of these surveys and investigations have recently been compiled by W. G. Hoyt in a report entitled "Power and Storage Possibilities of Salmon River, Salmon to Stanley." This report, which is in manuscript form, is open for public inspection at the district offices of the U. S. Geological Survey, Boise, Idaho, and Salt Lake City, Utah; and at Washington, D. C. The maps referred to in this report are published in seven sheets printed in two colors, entitled "Plan and Profile, Salmon River, Salmon to Stanley," and may be purchased from the Geological Survey, Washington, for 70 cents.

The report indicates that eventually nearly 2,000 feet of fall in the river may be utilized at 19 power sites at which it would be possible to develop 84,000 horsepower for 90 per cent of the time, or 114,000 horsepower for 50 per cent of the time. With regulation at certain storage sites which are described in the report, 119,000 horsepower could be developed for 90 per cent of the time, or 175,000 horsepower for 50 per cent of the time. The development of power in this region, however, will probably not take place faster than the development of its mining activities.—Department of the Interior.

PICTURES BY WIRE.*

By Charles T. Schrage,

Division Employment Supervisor, American Telephone and Telegraph Co.

The idea of transmitting pictures by wire is not new. It was worked out rather crudely some twenty-five years ago, but was not successful in the commercial sense, though interesting as an experiment. The transmission of pictures by electricity was made practical by the engineers of the Bell System through the combination of some of the old ideas of picture transmission with the modern vacuum tubes and other telephone apparatus. The big majority of the parts of the picture-transmitting machine consists of modified telephone apparatus, which has been adapted to the purpose.

The Bell System first demonstrated this apparatus at the time of the Republican National Convention at Cleveland in 1924. A transmitting machine was set up at Cleveland, and the pictures of the convention were sent to New York during the progress of the convention. The apparatus was next moved to New York and Chicago to cover the Democratic National Convention in the same year. Pictures were transmitted from New York to Chicago. A number of pictures were sent during the opening days of the convention, and we continued to transmit until we were exhausted, which, as I recall, was about July 4, at which time the delegates were still going strong, with no prospects of adjournment. The final demonstration of the apparatus was given at the time of President Coolidge's inauguration on March 4, 1925. A transmitting set was installed at Washington, and transmitted simultaneously to receiving sets at New York, Chicago, and San Francisco.

New York, Chicago, San Francisco, Atlanta, Los Angeles, Cleveland and Boston stations are now in service, and at the present time, the installation of an additional set at St. Louis is practically complete.

This perhaps covers the "historical" development of the picture apparatus and service, if a year or two may be said to be history.

In preparing a picture for transmission, it is necessary to prepare a 5 x 7 positive film. This film is wrapped around a

*Reprinted from *The Camera*, Nov., 1926.

cylinder, which is very similar to the old-fashioned phonograph record, except that it is arranged like a skeleton, so that

Courtesy of the American Telephone and Telegraph Company

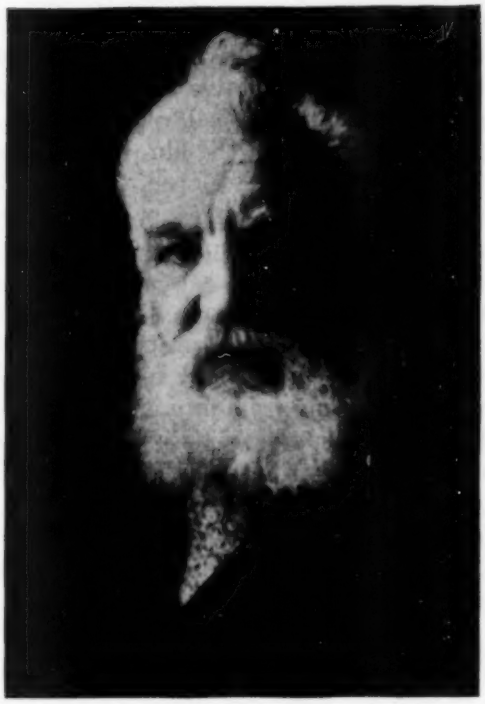
"INTERIOR SCENE"—FROM RECEIVED NEGATIVE, TRANSMITTED FROM CHICAGO TO NEW YORK. INTERESTING ON ACCOUNT OF FINE DETAIL, BUT CORRESPONDINGLY HARD TO REPRODUCE. THE ORIGINAL TRANSMITTED PHOTOGRAPH SHOWS SLIGHT VERTICAL LINES. OUR HALF-TONE ENGRAVER SUCCEEDED IN LOSING THE LINES AND ONLY THE ORDINARY HALF-TONE DOTS APPEAR.

light may penetrate the positive film from the outside, and strike a photo-electric cell, which is situated at the center of the cylinder. Outside of the cylinder a light system is arranged, consisting of a small automobile headlight lamp, a condensing lens, and a positive lens which focuses the beam of light to a sharp point on the surface of the positive film. This light penetrates the film, and strikes the photo-electric cell within. It is evident, therefore, that the amount of light striking the cell is governed entirely by the density of the positive film at the point where the light strikes; thus the intensity of this light is a true measure of the darkness or lightness of the picture.

The photo-electric cell is a small glass tube containing potassium, and has the unique property of controlling a flow of current through it in direct proportion to the amount of light striking the cell. Thus we have a current going out over the line, which is proportional to the light striking the cell, and in turn proportional to the density of the film. The current from the photo-electric cell is superimposed upon a 1300-cycle frequency, much as the voice in radio is superimposed upon a given wave length. At the receiving end, this frequency is "tuned in" and passed through a light valve.

The light valve consists of a string galvanometer which is a horizontal metal ribbon vibrating in a locally generated magnetic field. This ribbon normally covers a small slot through which a light passes to be focused upon a sensitive unexposed film, which is wound on a cylinder similar to that at the transmitting end. As the current from the transmitted photo-electric cell flows through the ribbon of the light valve, the ribbon vibrates, due to its reaction with the magnetic field, and the amplitude of this vibration is proportional to the amount of current through the ribbon. As the ribbon vibrates, it uncovers more or less of the slot, and so permits more or less light to fall upon the unexposed film. The height of the uncovered portion of the slot is proportional to the amplitude of vibration of the ribbon, which is in turn proportional to the amount of current passing through it, the amount of light falling on the transmitting photo-electric cell, and the density of the original positive film at the transmitting end. The amount of light falling upon the receiving unexposed film, and the consequent exposure of this film is, therefore, seen to be directly proportional to the density of the transmitting positive.

The above reasoning is correct for one point on the films. The picture, however, is built up by rotating and spiraling both of the films on their cylinders along a lead screw, just as the needle of our old-fashioned phonograph moved along the groove in the record; except, in this case, the record may be said to be moving while the needle stands still. It is essential, of course, that the two films start simultaneously, and move in absolute synchronism throughout the period of transmission. This is effected by means of tuning forks at either end of the circuits. The sending end tuning fork controls the speed of a motor at the sending end, and also sends a current out over the line superimposed upon a 400-cycle frequency.



Courtesy of the American Telephone and Telegraph Company

ALEXANDER GRAHAM BELL, INVENTOR OF THE TELEPHONE—REPRODUCTION IS FROM RECEIVED NEGATIVE WHICH WAS TRANSMITTED BY TELEPHONE WIRE FROM SAN FRANCISCO TO CHICAGO.

This current is "tuned in" at the receiving end, and sent thence to another tuning fork, which in turn controls the receiving motor. The two forks are thus kept together, the associated motors revolve at the same speed, and both films are kept moving in exact synchronism. The transmitted picture is in no sense instantaneous, as it is a result of a vast number of small exposures, which are built up to make the picture as the film revolves.

The total time of transmission is seven minutes. It is obvious that the prime necessity in picture transmission is speed. The shortness of the actual time on the machine indicates, I think, the importance of the time spent on the photographic part of the work. Where the machine time is seven minutes, the photographic time may run to an hour and one-

half, or two hours. At the transmitting end, it is usually necessary to copy a print, and to develop, fix, wash and dry this negative. From the negative a 5 x 7 positive is made and this positive must, in turn, be developed, fixed, washed and dried. At the receiving end, the film taken from the machine is a negative, and must be developed, fixed, washed and dried in the usual way. After this, prints must be made and the prints finished. In all of the photographic processes, we endeavor to use as much speed as is safe. However, we dare not take chances which might ruin a valuable negative.

The commercial uses of the picture service cover a great many fields. The Telephone Company takes the position of a carrier, and will accept a picture from any one who may care to send it for delivery to a specified person. We do not take any pictures ourselves or distribute any pictures to subscribers.

The most evident use of the service is for newspapers. It is entirely feasible to print in the afternoon papers pictures of events which occurred at noon in other cities. Police pictures, rogues' gallery photos, or thumb prints can be sent with perfect accuracy. In one case a picture of a thumb print of a noted criminal was sent from New York to Chicago, and the man identified at Chicago from this picture. The time in this particular case, from the moment that the thumb print picture left New York to the time the name of the man was wired back, was 61 minutes. Banks have used this method to identify signatures. Many different sorts of advertising material have been sent. Mechanical drawings, military maps, legal documents, display photos, pictures of merchandise samples, buildings for sale, motion picture "stills," are a few of the other types of pictures which may be sent.

As a point of information, the charges are: from Chicago to New York, $20.00 for one picture; from Chicago to San Francisco, $35.00; New York to San Francisco, $45.00; and from any one point to the other two simultaneously, $50.00.

Pictures are now being handled daily on a commercial basis, and there is every indication of a continuing growth in the amount of this business handled. From a mechanical standpoint, we believe that the apparatus is entirely satisfactory for any type of business where an ordinary contact photograph could be used. We look forward to the day when the transmission of photographs over telephone wires will be as commonplace as the transmission of the voice over those same wires in the ordinary long-distance call.

THE LONG AND THE SHORT OF IT IN AGRICULTURE.

AN OPEN SUGGESTION BY E. G. CAMPBELL,*
Purdue University.

There has long been a feeling among business minded farmers that it is possible to school a youth in the necessary principles of practical agriculture in far less time than four years. Therefore, most Land Grant colleges are familiar with the "short course problem." As a rule, however, modern schools of agriculture favor the traditional four years, and insist that the first two of the four be spent in the learning of fundamentals which shall serve as prerequisite for the last two. In many instances, as a result of this clash of the farmer's wit with the educator's tradtion, two agricultural curricula have been organized and maintained under one institutional roof—the "long course" and the "short course." This looks like a schoolhouse divided against itself and the cleavage becomes more noticeable when a state college maintains from public funds, a short course for students who are less advanced than high school graduates.

If, therefore, an agricultural college is to accept for its short course, as for the long course, only those individuals who have completed the twelfth grade in the public schools, then the freshman "long horn" is in no wise superior to the freshman "short horn" and in college what is good for the one is not too good for the other. If it is best for a would-be short course man to begin with elementary agricultural subjects, it is best also for the would-be long courser because he, too, came to college with that purpose uppermost in his mind, and sometime, in the very nature of the school, he must study elementary agriculture.

This is to suggest that there be no separately designated long and short courses, but that a four year curriculum be built logically upon a one year vocational basis, offering in the following three years many optional lines such as will lead respectively to agricultural research, the deeper problems of vocational agriculture, agricultural education, business administration, sociological and economic outlook, industrial and financial agriculture, etc.

A general and tentative schedule for this suggested vocational basis is stated in the following two-year outline:

*In charge of Agricultural Botany.

AGRICULTURAL CURRICULA ON AN ELECTIVE SHORT COURSE BASIS

Freshman Year.

Animal Industries [2]	*Plant Industries* [3]	*Agricultural Chemistry* [4]
1st Semester	*1st Semester*	*1st Semester*
(2) Animal Husbandry 1	(2 2/3) Horticulture 1	(3) Chemistry 1
(2 2/3) Poultry 1	(2 2/3) Crops 1	(2) Animal Husbandry 1
(3) Dairy 1	(2 2/3) Floriculture 1	(2 2/3) Poultry 1
(2 2/3) Farm Mechanics 1	(2 2/3) Farm Mechanics 1	(2 2/3) Dairy 1
(2 2/3) Crops 1	(3) Entomology 1	(2 2/3) Crops 1
(3) English 1	(3) English 1	(3) English 1
(1) Ag. Problems 1	(1) Ag. Problems 1	(1) Ag. Problems 1
(1) M. T.†	(1) M. T.	(1) M. T.
18*	18 2/3*	18*
2nd Semester	*2nd Semester*	*2nd Semester*
(2) Animal Husbandry 2	(2 2/3) Horticulture 2	(3) Chemistry 2
(2 2/3) Poultry 2	(2 2/3) Crops 2	(2) Animal Husbandry 2
(2 2/3) Dairy 2	(2 2/3) Floriculture 2	(2 2/3) Soils 1
(2 2/3) Soils 1	(2 2/3) Soils 1	(2 2/3) Horticulture 1
(1 1/3) Farm Management 1	(1 1/3) Farm Management 1	(3) English 2
(3) Entomology 1	(3) English 2	(3) Entomology 1
(3) English 2	(1) Ag. Problems 2	(1) Ag. Problems 2
(1) Ag. Problems 2	(1) M. T.	(1) M. T.
(1) M. T.	17*	18 1/3*
19 1/3*		

Sophomore Year.

1st Semester	*1st Semester*	*1st Semester*
Animal Husbandry 3	Horticulture 3	(4) Chemistry 3
or	or	(3 1/3) Botany 1
(2 2/3) Poultry 3	(2 2/3) Floriculture 3	(3) Mathematics 1
or	or	(3) Entomology 2
Dairy 3	Crops 3	(1) M. T.
(3) Chemistry 1	(3 1/3) Botany 1	(4) Elective
(3) Mathematics 1	(3) Chemistry 1	14 1/3—18 1/3*
Botany 1	(3) Mathematics 1	
(3) or	(3) Entomology 2	
Biology 1	(1) M. T.	
(3) Economics 1	16*	
(2 2/3) Crops 2		
(1) M. T.		
18 1/3*		
2nd Semester	*2nd Semester*	*2nd Semester*
Animal Husbandry 4	Horticulture 4	(4) Chemistry 4
or	or	(3 1/3) Zoology 1
(3 1/3) Poultry 4	(2 2/3) Floriculture 4	(3) Mathematics 2
or	or	(3) Entomology 3
Dairy 4	Crops 4	Histology 1
(3) Chemistry 2	(3 1/3) Botany 2	(3) or
Mathematics 2	(3) Chemistry 2	Economics 1
(3) or	Economics 1	(1) M. T.
History 1	(3) or	17 1/3*
Zoology 1	History 1	
(3 1/3) or	(3) Entomology 3	
Botany 2	(1) M. T.	
(1) M. T.	16*	
(4) Elective		
13 2/3—17 2/3*		

Under this plan of unification three advantages seem eminent:

1. *The vocational year offers the solution of the short course problem.*

The day now is when certain professional and industrial courses in colleges and universities must demand an agricultural foundation. In this very hour the tillers of the soil in our country need in their supporting ranks, more agricultural bankers, agricultural lawyers, agricultural ministers, agricultural sociologists, agricultural industrial leaders, etc.

One or two years under this vocational foundation plan would admirably serve the needs of the hour in this respect. Any student, at the close of any semester, may drop into other courses, or he may with self respect withdraw to the farm, having to his credit a practical and logically completed short course and a definite resuming point, should he ever return to college. For such "out" students the college shall have done its very best to lay the beginning of a broad, constructive agricultural service and a progressive patriotic citizenship. One can easily believe, when a student withdraws from such a curriculum, that he takes with him wherever he goes, a wholesome attitude towards the problems of modern agriculture, and a warm loyalty to the college that taught him. Such genial "outs" are not commonly produced under the regular traditional four year plan, but rather with its two years of basic fundamentalism it produces a morbid thing known as a "student mortality list."

2. *The vocational year bridges the much lamented gulf between the high school and the college.*

The first year under this plan may be made to serve as a tremendously effective orientation period for freshman students. If it is found that some must go home, let the college send them in fatherly good will, and endowed with a fitting blessing. Those who may stay, let them pass forth into the second year impressed with the need of botany, biology, mathematics, chemistry, etc.; that they may thereby enter intelligently into those studies that lead toward creative activities. In this

*Semester hours.
[1]The general Agriculture an Agricultural Education lines may be elective at the beginning of the Junior year
[2]Animal Husbandry, Poultry, Dairy, Veterinary, Science, etc.
[3]Horticulture, Agronomy, Floriculture, etc.
[4]Agricultural Chemists must begin chemistry in the Freshman year.
†Military Training is reduced to one credit per semester.

forward-going group of students there should be not only potential farmer-citizens of the highest type, but potential research men, doctors of philosophy, future administrators of agricultural education, social and economic reformers, etc.

3. *The vocational year offers greater opportunities to practice the much heralded "problem method" of teaching.*

No given problem can be solved till that problem has been judiciously set. Agricultural problems should have their settings in agriculture, not in biology, chemistry, mathmatics, etc. The solution of a problem may call for any one or several of these fundamental sciences. Any technical subject, however, that is forced suddenly and unrelatedly upon a freshman, thereby crowding out subjects for which he already has a yearning, is likely to breed indifference and carelessness, but that same subject will become vitally interesting if called for in the solution of a chosen problem.

The vocational year, therefore, should be the problem setting period of a college man's life, a period in which, under the choicest kind of instructorial guidance, he receives the magic touches that inspire him for his life's work.

It is known that several traditions stand against the adoption of this vocational basis of a four year course in agriculture.

There is an old time feeling among college professors that no electives should be permitted in the freshman and sophomore years. There are some feasible arguments to support this feeling but the modern trend in agricultural education is threatening to break this professorial tradition.

Through the extension departments and county agent systems of Land Grant colleges, boys and girls of the rural communities are being inspired to enter college to study certain definite lines of agriculture. If through his pig club or calf club a boy on the farm becomes interested in animal production, he may rebel against spending his first days at college in studying chemistry, botany, mathematics, a non-credit course in English theme writing, the nervous systems of earth worms, etc. If through his apple club or corn club a boy becomes interested in plant production, he is not likely, in his early college days, to take kindly a course in hen house sanitation, a preparation course for show-ring live stock, the mendelian principles of a trihybrid, etc. Most Engineering schools allow their freshmen to enter as Mechanicals, Electricals, Civils or Chemicals, etc.,

even though little or no actual engineering is taught in the first year. Agricultural schools could do better by not only admitting their freshmen as Horticulturals, Poultrymen, Dairymen, Agricultural Chemists, etc., but by actually setting them to work on the unprerequisited problems of their chosen lines.

It has always been assumed in certain professional circles that a college curriculum should have at its very beginning a definite list of subjects upon which advanced work must be based. In general this assumption is well founded. Engineering is dependent upon mathematics, therefore, mathematics should be included in the freshman year. Agricultural chemistry is based upon chemistry. Chemistry should be placed in the first year, etc. But is there any one science that is equally fundamental to all lines of agriculture?

There seems to be a general collegiate tendency to overestimate the value of prerequisite courses. One group of professors may say that elementary bacteriology cannot be taught to students who have not had one year of general biology. Agronomy professors may say that they cannot teach elementary field crops to any student who has not had at least one semester of general botany, etc. All this is equivalent to acknowledging weakness and inversatility.

It is easy to suppose, if figures do not lie, that chemistry 1 should precede chemistry 2, and that botany 2 should follow botany 1, etc., but if a professor says his students in elementary soils must have as prerequisites, chemistry, physics, and geology, one wonders just what the job of a soils professor is, and why with such prerequisites an elementary soils course should be necessary. An exacting botany professor may with a degree of reason prerequisite his course with general biology, physics, chemistry, farm economics, etc. In justification of these high demands he may truly say that plants are biologic in nature, physio-chemic in action, and highly economic in utility.

Nevertheless it is possible for an ordinary teacher to make his unprerequisited botany course interesting and profitable, but perhaps the job would be less difficult if his students had previously studied something (elementary agronomy, horticulture, etc.) that would have impressed them with the need of botany. And yet, on the other hand, by the proper selecting of class room and laboratory materials, botany can be

made, in its very nature, agronomic or horticultural. In like manner, to impress the student that a soil expert needs chemistry, physics and geology, may be made one of the objectives in the teaching of elementary soils, or on the other hand, the course in soils may be made chemical, physical and geologic in its very content.

THE TELEPHONE THAT JACK BUILT.

By O. E. Underhill,
Lincoln School of Teachers College.

This is the man that listened to a voice through the telephone.

This is the air that vibrated the ear-drum of the man that listened to a voice through the telephone.

This is the tin disc in the receiver that pushed the air that vibrated the ear-drum of the man that listened to a voice through the telephone.

This is the magnet whose fluctuations in strength caused the tin disc in the receiver to push the air that vibrated the ear-drum of the man that listened to a voice through the telephone.

This is the carbon button whose varying resistance caused the variations in current that caused the fluctuations in the strength of the magnet that caused the tin disc in the receiver to push the air that vibrated the ear-drum of the man that listened to a voice through the telephone.

This is the tin disc in the transmitter whose vibrations caused the varying pressures that caused the varying resistance of the carbon button that caused the variations in current that caused the fluctuations in the strength of the magnet that caused the tin disc in the receiver to push the air that vibrated the ear-drum of the man that listened to a voice through the telephone.

This is the air that pushed against the tin disc in the transmitter that caused the varying pressures that caused the varying resistance of the carbon button that caused the variations in current that caused the fluctuations in strength of the magnet that caused the tin disc in the transmitter to push the air that vibrated the ear-drum of the man that listened to a voice through the telephone.

This is the man whose vocal cords set the air in motion that pushed against the tin disc in the transmitter that caused the varying pressure that caused the varying resistance of the carbon button that caused the variations in current that caused the fluctuations in strength of the magnet that caused the tin disc in the receiver to push the air that vibrated the ear-drum of the man that listened to a voice through the telephone.

EXTENT OF ORCHARD HEATING IN SOUTHERN CALIFORNIA.

The fruit-frost service of the Weather Bureau, in charge of Mr. Floyd D. Young, is compiling data on this subject, which when completed will form the first authoritative information with regard to it. The work is divided into eight districts, for each of which it is hoped to have complete data before the spring of 1927. In summarizing the work for the Redlands-San Bernardino district, Mr. A. W. Cook, of the Weather Bureau, writes as follows (California Citrograph, July, 1926):

"There are 29,691 acres of citrus trees in the entire Redlands-San Bernardino fruit-frost district, of which 5,789 acres, or 19.5 per cent, are equipped with heaters. The increase in acreage protected since the spring of 1925 is 2,977, or 51.4 per cent of the total. On the basis of fifty 9-gallon oil heaters to the acre, 2,483,550 gallons, or roughly 250 carloads, of oil are required for one filling of the heaters. The Redlands section alone requires about 187 carloads of oil for one filling."

NEW TRENDS IN GEOMETRY TEXTBOOKS.

By TRUMAN P. SHARWELL,

Graduate Student, Teachers College, Columbia University, Formerly Instructor in Mathematics, Bogota, N. J., High School.

The geometry textbook is a significant measure of the advances made in the teaching of geometry. What are these outstanding tendencies and what has brought them about?

It would seem that many of the improvements in new textbooks such as those by Seymour, Avery, Austin, Roland Smith, and Clark and Otis are traceable to an increasing recognition of the dominant aim of the teaching of plane geometry in high schools and a deeper insight into the difficulties of the pupil.

This shift of emphasis as to the dominant aim—and how important this is to the future of the teaching of geometry!—is clearly expressed by Clark and Otis (John R. Clark and Arthur S. Otis: *Plane Geometry*, Experimental Edition, Revised, Copyright, 1925, 1926, published by The Lincoln School of Teachers College, Columbia University, New York City) in the introductory word "To the Pupil" in answer to the question "Why should I study geometry?" "We tell you frankly that the *truths* you learn in this book you will not apply to everyday affairs as often as those of some other subjects. You will learn many new and interesting facts about space, about lengths and areas, about symmetry and design. But to teach you these facts is not the chief purpose of this book. Its chief purpose is to teach you how to think, how to reason, how to investigate and discover new facts for yourself, how to convince others of the truths you have discovered, how to prove that what you believe is true.

"Do you wish to be resourceful—to know how to attack new problems in such a way that you can solve them? Do you wish to express ideas in clear, concise English? If you study geometry with a desire to learn, you will take great enjoyment in it. You will enjoy convincing others of what you believe and proving it beyond doubt."

Pupils don't care very much about the practical value of geometry. If this were our only reason for teaching geometry, we should probably find it difficult to justify geometry in the minds of our pupils or to arouse any enthusiasm for it among them. But they do like to argue; they do call it fun to try to convince others that they are right.

What, then, are these new trends in geometry textbooks?

1. Psychological order. There is a gradually increasing tendency toward a psychological arrangement of subject matter. According to this criterion, it would be better to postulate propositions whose proof does not add to the pupil's conviction of its truth. No amount of repetition of the proof of the vertical angle proposition will increase the pupil's conviction. For the same reason, Clark and Otis treat the theorem "The perpendicular is the shortest line that can be drawn from a point to a line" as a postulate. There is also a tendency not to require any formal proof of the first two congruence theorems. Progress in this direction would be swifter if they were not still required by certain examining bodies. Dr. John R. Clark has called the formal proof of these theorems "the graveyard of plane geometry." At the outset, the proof by superposition discourages the pupil. It is difficult and comes when he is not ready for it. An experimental proof plus postulation is sufficient. There thus is a tendency toward an increasing number of postulated statements rather than an irreducible minimum.

2. Use of analysis. Pupils frequently say of a proof: "I understand very well that step 3 is right, but what I don't understand is how did the author know that that was the step to take?" This difficulty has led pupils to the use—always fatal—of rote memory in the reproduction of proofs, as a substitute for active reasoning. Roland R. Smith, as a result, in his *Beginners' Geometry* (Macmillan Company, Chicago, New York, etc., 1925) adopts on the title page the slogan "Geometry Understood, Not Memorized." The second trend, then, is the use of some form of analysis of the proof, to meet this evil.

Analyses are valuable for four reasons: (1) they give at the outset the gist of the proof, thus enabling the pupil to follow the proof more intelligently; (2) they show how the proof may have been discovered and how if necessary it may be worked out again; (3) they furnish a powerful method of attacking originals; and (4) they make for mastery and understanding and tend to counteract the tendency to mere memorizing.

The Sykes—Comstock text (Mabel Sykes and Clarence E. Comstock: *Plane Geometry*, Rand McNally and Company, Chicago and New York, 1922), contains excellent full analyses. Seymour (F. Eugene Seymour: *Plane Geometry*, American Book Company, Chicago, New York, etc., 1925) omits all proofs except about a half dozen; he gives analyses consisting of questions

which suggest the proof. Avery (Royal A. Avery: *Plane Geometry*, Allyn and Bacon, Chicago, New York, etc., 1925) gives an excellent summary of methods of proving certain things, such as angles equal, lines equal, lines parallel, etc. Preceding each proof he gives a "Plan of Attack" consisting of three items: class (e. g., inequality of lines), methods known (by sections), and the method to be used.

3. An emphasis on the *discovery* of truths. This is a new kind of geometry, a more interesting kind. It brings joy to the pupils to discover truths for themselves. In the kind of geometry we studied, the truths were always given by the teacher or textbook. There are two important things in geometry: first, the *discovery* of truths, and, second, the establishment of the truth by an irrefutable argument. The Clark-Otis text is the originator of this principle.

4. Recognition of individual differences. The Clark-Otis geometry has the pupil keep a record of his progress and has a series of challenges and starred originals for the brighter pupils.

5. Definitions not given until a need is felt. In William A. Austin's *Laboratory Plane Geometry* (Scott, Foresman and Company, Chicago, New York, etc., 1926) definitions are learned incidentally through constructions. Clark and Otis develop the introductory ideas around the topic of symmetry. In Roland Smith's text the order of presentation is: (1) familiarity with the fact; (2) the formal statement of the fact; never the reverse order.

6. The use of illustrations. Avery's geometry contains a large number of fine pictures showing the practical uses of geometry.

7. The conscious use of developmental exercises. Roland R. Smith makes clever use of simple originals to lead up to the theorem. By means of these he can separate a theorem into its constitutent difficulties and treat each by itself.

These seem to be the significant trends in recent textbooks. They appear to be in the right direction.

Bequest of business property valued at $500,000 to George Peabody College for Teachers, Nashville, Tenn., by a living donor who retains income from the property during her life, makes possible the erection at an early date of a new art building, plans for which are already in the hands of the architect. Many rare objects of art accompany the gift, which will be made the nucleus of an art museum at Peabody.—*School Life.*

SCIENCE AND EXPERIENCE.

By Wm. G. Fuller,

State Normal School, New Paltz, N. Y.

The child enters school a veritable question box. For a brief period of years, the world has presented a series of interesting questions, most of which have either been unanswered, or answered in an unsatisfactory manner. And through the grades, the principal industry has been to present to the pupils more problems for them to solve, many of the problems not being closely related to daily life.

The effect of the present school course is to repel, rather than to attract the youth, and school remains the dreaded ordeal rather than the pleasant adventure it should be. The lack of relation of the school curriculum not only to the daily life of the youth, but to the life he may expect to follow as an adult, may account for this distaste to a large extent.

All young people, the girls as well as the boys, take a lively interest in their environment, and possess a natural desire to understand and interpret their surroundings. It is in this relationship that the study of the various sciences has the greatest value, as indicated by the large number of students that elect the science courses.

The past twenty years have seen a complete change in the nature of the questions asked by the examining boards. Formerly the type of questions asked by the boards were of a direct informational nature whereas now those of a reasoning type prevail. This is a change for the better, since it puts the burden of passing the examinations on the pupil by testing his reasoning ability. But while this type of question has undoubtedly improved the examinations, it has also greatly increased their difficulty.

Again the lack of practical experience which is evident with so many of the immature students is a severe handicap to the proper mastery of the subject. If the teacher can find an illustration taken from the past experience of the pupil, of the new point to be discussed, it makes a valuable point of departure for the development of the new idea.

To the boy interested in mechanics, or the boy on a farm who has been in immediate contact with so many of the actual applications of physical principles, this point of departure is an easy matter, but with the average girl of today, brought up under artificial conditions of modern life, the illustrations are limited, because of the narrowness of their experience.

To remedy this lack of experience, the author has tried with success the following plan. Each student, some months before the beginning of the course in Physics is provided with a sheet containing a list of observations to be made on simple phenomena, that can be seen about any home.

A few of the suggested observations, enough to show their general nature, are as follows:

(a) Notice the tendency of an automobile when rapidly turning a corner.
(b) Sprinkle a few drops of water on a hot stove, and notice the appearance and action of the drops
(c) Watch for the reflection of the setting sun in the eastern windows. Does window glass, then, transmit all the light received?
(d) Watch for illustrations of the fact that sound requires time to travel.
(e) Examine labels on electrical appliances to determine the amperage employed.

The usual order for procedure in developing a new principle is to first perform a series of experiments in order to properly develop the law, and then to discuss as many applications as time will permit. The important laws of elementary physics are comparatively few in number, but the applications of these laws are innumerable. The limited experience of the students has brought them into contact with so few of these applications however, that on examinations many fail to see the connection between the question asked and the general principle involved.

Since science has been well defined as classified knowledge it is well that pupils be taught to generalize and trained to list under the proper principle, the innumerable phenomena which constantly surround us on every hand.

Even though the average class has been well drilled on a special phase of the subject, yet there seems to be a wide gap that needs to be bridged between a clear understanding of the major principles involved, and the ability to associate the applications under the proper head.

The following scheme, which is based on the fact that language is the means for the conveyance of thought, and that therefore the question must contain the germ of the answer, has produced excellent results in solving this difficulty.

First, a condensed list of the principles of the special phase of the subject recently covered is drawn up. It has been found that a dozen short phrases sum up the essence of the matter in the subject of heat as covered in the ordinary course of the high school of today.

The list is as follows:

1—Heat is the rapid vibration of the molecules.
2—The maximum density of water is at 4°C.
3—Metals are good conductors.
4—Liquids, gases, wood and rubber are poor conductors.
5—Heat expands, cold contracts.
6—Compression and friction produce heat.
7—Objects heat and cool at different rates.
8—Black objects are good absorbers, white objects are good reflectors.
9—Liquids absorb heat in vaporizing.
10—Pressure lowers the freezing point.
11—The boiling point varies directly with the pressure.
12—Ice absorbs heat in melting.

The pupils are allowed to read and comment on this list until they are sure they recognize the laws involved. Then a list of applications are written on the board, and the students requested to underline the words relating to the subject of heat. These will be found to consist usually of the nouns and verbs. The students are then asked to examine the list of heat principles and locate either the same words as underlined or their synonyms. At once the answer to the question is seen.

Typical questions follow.

1—Why does a *damp* towel feel cool when hung in a *breeze*?
2—Why is *loose* dry snow a poor conductor?
3—Why do Germans *cook* potatoes under *pressure*?
4—Why does an auto tire feel *hot* when just pumped up?
5—In freezing ice cream, why is the cream placed in a *metallic* container?

This same idea can undoubtedly be applied to other subjects.

BIOLOGY NEEDS MATHEMATICS.

Mathematics, the bugbear of many students, will be as important in biological research during the coming generation as it is now in the so-called "exact sciences" of chemistry and physics, and it will no longer be possible for the scientifically-inclined young man to flee from a study toward which he is disinclined into the biological field. Dr. Horatio B. Williams of Columbia University prophesies that a knowledge of higher mathematics will some day be required of advanced students in the sciences just as a reading knowledge of French and German now are.

However, Dr. Williams holds out some encouragement to the student who believes he has a "non-mathematical" mind. He doubts whether such a mind really exists. It is undoubtedly true, he states, that some students can master mathematics much more easily than others; but with patience and the guidance of the right kind of teachers even they can eventually conquer the subject.—Science News-Letter.

EVOLUTION FIGHT IN CAROLINA.

The evolution issue, thought dead in North Carolina, threatens to crop up again at the coming session of the legislature. A fundamentalist committee has a bill in preparation, which they state they will introduce early in January.—Science News-Letter.

EFFECTIVENESS IN LABORATORY WORK IN CHEMISTRY.

By HERBERT R SMITH,
Lake View High School.

The world today readily acknowledges the contributions of science which have revolutionized the mode of living in the past quarter of a century. All of this progress has been won by the application of the scientific method and the laboratory practice is by far the most important share of the scientific method. Not a scientist but an educator has made this astonishing statement.

"One of the only two articles that remain in my creed of life is that the future of our civilization depends on the widening spread and the deepening hold of the scientific habit of mind; and that the problem of problems in our education is therefore how to discover and how to mature and make effective this scientific habit. . . . . It represents the only method of thinking that has proved truthful in any subject. That is what we mean when we call it scientific.'—Professor John Dewey.

If this be so why do we teachers of science allow ourselves to be so lukewarm about the possibilities of the scientific method? Our want of enthusiasm and faith is at once the greatest hindrance to effective laboratory teaching. We do not look askance at the self-binder and stick to the cradle and sickle. We do not shy off from the automobile (which might be quite logical since it kills an average of 70 persons per day in the United States) and climb into the ox cart. Then I ask, yes I demand, that you be consistent in that you employ this greatest of all human devices to set both you and your pupils on the way to achievement. You can not expect, you may not wish to put all chemical data at the command of your pupils for that is impossible. But you must if you do your duty as a teacher, teach them how to think, and organize facts into a code of effective action, and how else would you want to do it except by becoming thoroughly familiar with the scientific method.

I know that the text-books say little of nothing about it. The text-book writer leaves this to the teacher and the teacher leaves it for the pupil to absorb in an unconscious way. It is said that the Phlogiston theory delayed the progress of chemistry by a hundred years. I think that I have found its counterpart in the teaching of chemistry. It is the text-book in current use. It is not my purpose to detract from the service that the text-

book has rendered. In an age outworn it served to open the door of a science rarely seen open. But a hundred avenues to chemistry are now open to every one. Who cares to see a few shells when he can visit the sea shore?

"The delicate shells lay on the shore;
The bubbles of the latest wave
Fresh pearls to their enamel gave,
And the bellowing of the savage sea
Greeted their safe escape to me.
I wiped away the weeds and foam—
I fetched my sea-born treasures home;
But the poor, unsightly, noisome things
Had left their beauty on the shore
With the sun and the sand and the wild uproar."

—Emerson.

The text-book is too much a museum of dead things. The facts in it are dead to modern youth because they are torn from their natural setting. Chemistry lives in the things all about us and in us and we must be interpreters of it and not embalmers. The chemistry of the text-book can not command the attention of modern youth when there are so many really attractive things to occupy the mind.

The worst offense of the text-book is that it robs the laboratory practice of its thrill and inspiration. If you are half through reading a book do you want any one to tell you how it all comes out? That is what the text does, particularly where lessons are assigned in it and recited previous to the laboratory work on that topic, or the text is used concurrently with laboratory practice. I know of only two modern laboratory books that do not refer directly to the pages of the text for the interpretation of laboratory data. Such reference is an admission that this topic is unsuited for laboratory method. If the pupil must be told what to think why bother with the experiment? A few months ago I reviewed a manuscript of a to-be chemistry text for a publishing house. I could not find any place in the laboratory manual where the pupil was required to do his own reasoning. He was told what to think about every thing so there was no opportunity for mental individuality.

The last five years has brought an astonishing increase of chemical facts and ideas. These are being incorporated into texts and rarely is any of the older material discarded. As a result of this the texts are becoming plethoric. There is too much mater-

ial to master it in a year, so some of it must be slighted. Frequently this happens to be the fundamentals, or they are lost sight of in the mass of chemical data. New technical terms are plentiful. Dr. Powers of Columbia University pointed out at the Philadelphia meeting of the American Chemical Society the great increase of terminology that appears only once in textbooks. Ten years ago the texts averaged 400 pages while now they range from 600 to over 800 pages. The only purpose that the texts serve in a suitable way is as a reference book. They lack the detail, the scope, and the style to serve as a reading book in chemistry. Besides there are other books that are admirable for this purpose.

When these problems are solved the main one still confronts us. It is the ungraded group of pupils that we are trying to teach as a class. The enormous increases of enrollment in the high school has brought into the student body many pupils with little educational background and little real desire to work. They have come up mechanically from the elementary grades with the others and they lack the ability to think or the desire to accomplish. This tendency has been intensified by supervisors who have upheld few pupil failures as an index of good teaching without making sure that adequate instruction was provided.

Our studies and tests at Lake View for the past three years give an average of 58% of those enrolled in my chemistry classes who are unable to profit by their individual work in the laboratory. I am reminded of a teacher who used to attend these meetings and frequently was a speaker on the programs. He always painted the success of his pupils in the most glowing colors and made all of us feel that he had no problems. We all have pupils whose work we are proud to own, but efficient teaching is promoted by knowing and mending our weak points rather than shouting our excellence from the housetops.

In the third year of our efforts we announce a solution of the problem. It has incited great interest among chemistry teachers when presented at meetings in Milwaukee and Philadelphia during the past year. It has been inspected by a number of visitors including those from the state university and it has been approved by them. We shall refer to it as the Lake View Group Method of Laboratory Instruction. For some years we had been finding an increasing number of pupils in the classes who learned very little as result of doing laboratory work. If the pace was set by the better portion of the class these in their

desperation resorted to evasion, copying and various forms of deceit. This destroys the regard for the truth which is the chief value of the teaching of science. If the work was slowed up to give comprehension for the weaker members, the more rapid workers lost interest, got into bad habits of wasting time, and did not develop. To avoid one evil seemed only to fall into another. The obvious remedy was to section the classes into two or more groups. This was first determined on the basis of ability by the Terman Test. Nearly half of the highest group however failed to make progress through inability to apply themselve to work, while others in the lower groups did satisfactory work through their persistency and determination. The revision of the groups on the basis of achievement suggested the desirability of allowing the pupil to place himself by his efforts. This stimulant to better work has been a very important factor in the plan.

A very serious fault of the class method has been to put all its members on the same level. In their own estimation the poorer ones feel that they are about as good as the rest so they fail to work. The main feature of the Dalton Plan of teaching is to put each pupil on an individual basis in order to show him his standing in comparison with the others. It is undoubtedly the best way to correct false estimations of self. This value is obtained by occasionally trying some or all in the individual work, and any who slow up are brought back to the lower group to work under closer supervision. The Dalton Plan is wasteful of teacher effort. There is no need of repeating the same instruction to one after another. The higher group is dismissed to laboratory work with little supervision but the others are kept together under close supervision while one or two perform the experiment. Frequent changes are made with the experimenters to give all some skill in manipulation, but the important part of seeing results and interpreting them is done by all. By repeated question the instructor can be sure that each one in this group understands the lesson, has written the record, and it is correct. There is no laborious correcting of note books in this plan. If equipment and supplies are limited the group method fits this fact by requiring less material.

By the Group Method it is found that some pupils in every class are able to do from three to four times the work of the slowest. This fact has made it necessary to reorganize the labora-

tory experiments on the basis of minimum fundamentals for the slowest with a liberal supply of extra and advanced work for the others. By this plan the whole class is kept together on the fundamentals and all who can, extend their work individually as they have time. On the days following laboratory work, review and drill exercises are prepared for the classes to study.

By the Group Method we have been able to reduce the number of failures to the few who will not work, to set a high standard of individual thinking and regard for the truth, to give an understanding of the scientific method, and to cultivate enthusiasm for chemistry even though it requires effort to understand its principles.

SCIENCE DINNER AT HARRISBURG.

Wednesday evening, Dec. 28, was the "red letter" occasion which marked the end of a perfect science day for the Science Section of the Pennsylvania State Education Association. The science dinner served in cafeteria style at The William Penn high school was a great success. This dinner was one of the first steps in the organization of a state science association. Speeches were made by a number of the members, first, on the plan and second, on the best methods of organization and procedure necessary to effect the same. It was unanimously voiced that there was a specific need for a strong state science association made up of units corresponding to the convention districts with these units united and centralized into a state organization, the meetings of which would be held in conjunction with the P. S. E. A.

It was brought out that there was immediate need for a state-wide study of science teaching problems from the grade school to the college; and that through such an organization these problems could be properly directed and studied with mutual deliberation and discussion. It was voted to have a committee of seven, one from each of the present convention districts of Pennsylvania, appointed by the president of the Section to perfect such an organization.

C. A. Gorgas of Peabody high school, president of The Langley Association of Science Teachers, pledged the loyal support and active cooperation of that association in the movement. Professor Gerald L. Wendt, Dean of the School of Chemistry and Physics, State College, and chairman of the Pennsylvania State Essay Committee, gave a brief talk on the importance of the participation of all science students in the American Chemical Society's prize essay contest. Glen W. Warner, Editor of SCHOOL SCIENCE AND MATHEMATICS, told of the activities of science organizations in other sections of the country and pledged the further support of that journal in extending the influence of the Pennsylvania Science Section.

The discussions were all informal. This gave the meeting an atmosphere of cordiality and good cheer. Dr. W. L. Eikenberry of the East Stroudsburg State Normal School presided.

C. E. BAER,

Secretary of the Science Section of the Pennsylvania Education Association.

THE METRIC SYSTEM OF WEIGHTS AND MEASURES AND ITS RELATION TO INTER-AMERICAN COMMERCE.

By F. Suastegui,

Mexican Commercial Attache, Washington, D. C.

The advisability of adopting the metric system in inter-American commerce can best be realized by analyzing the handicaps affecting trade between countries using a different system of weights and measures and the facilities enjoyed by those which have adopted common standards. However, this subject is only a part of a larger problem created by differences in language, money, weights and measures, and to visualize the entire field it is well to compare inter-American trade with European-American trade.

The metric system, on account of its simplicity, has been adopted by practically all civilized countries with the exception of the United States and the United Kingdom. Continental Europe and Latin America use the Kilogram, the Liter and the Meter as measures of weight, capacity and length. Therefore, quotations, invoices, bills of lading, freight rates and cost calculations are identical for seller and buyer, for importer and exporter.

Furthermore, most shipments are made on a CIF Latin American port basis and very often prices are quoted in the gold coin of the Latin American buyer; correspondence is generally conducted in Spanish or Portuguese and European salesmen and representatives speak those languages fluently. Whenever possible long terms are granted through negotiable acceptances, packing requirements and local conditions are studied and the general rule observed is to make matters as easy and comfortable as possible for the buyer. "The customer is always right" seems to be the slogan that made German success possible in the export field.

On the other hand, the American exporter has met this competition through quantity production of standardized manufactures and automatic factory equipment, also through the undisputed superiority of certain lines, but working under the great handicap of a total difference in export methods. The system of weights and measures used in this country is almost incomprehensible for the average Latin American, and trade has to be conducted through a limited number of import and export firms with personnel trained specially for the purpose.

In the metric system all standards are subdivided in ten, one hundred or one thousand equal fractions, just like occurs with dollars and cents, or the units are multiplied by ten, one hundred or one thousand. The system is further facilitated through the use of significative names for the various fractions or multiples, using the following words:

deci = 1-10th	mili = 1-1000th	hecto = one hundred
centi = 1-100th	deca = ten	kilo = one thousand

These words, in combination with the various units, produce clear and comprehensible denominations such as the following:

centimeter = 1-100 of a meter	miligram = 1-1000 of a gram
milimeter = 1-1000 of a meter	hectoliter = 100 liters
kilogram = 1000 grams	decaliter = 10 liters

In receiving quotations or figuring the cost of merchandise purchased in the United States, the Latin American importer has to convert bushels to dry liters, pounds to kilograms, tons to metric tons, gallons to wet liters and yards to meters. However, the standard Customs weight of the oats, barley, corn and wheat bushels is respectively of 32, 48, 56 and 60 pounds, but the weight varies with the different states.

The Winchester bushel contains 2150.42 cubic inches, but in Nebraska it measures 2150; in Connecticut and Idaho the fruit bushel contains 2564 cubic inches and 2680 in Missouri; in some states the law calls for heaped measures, in others leveled and still in other states the law requires them to be full or slightly heaped.

In reality, the bushel represents a common name for a heterogeneous group of measures varying in capacity with the state and the product measured, and the only safe method for the Latin American importer is to purchase by the avoirdupois weight, instead of capacity measures.

In converting pounds to kilograms the Latin American importer has to remember that the avoirdupois pound of 454 grams is subdivided into 16 ounces and each ounce into 16 drams, being used for all commodities excepting drugs and precious metals, when the troy pound, weighing 373.58 grams is used along with its subdivisions of 12 ounces, 240 pennyweights and 5760 grains in the case of precious metals and 12 ounces, 96 drams, 288 scruples and 5760 grains in the case of drugs. However, very few people in Latin America and Continental Europe are acquainted with these discrepancies.

Speaking of tons, there is a terrible confusion, as the short ton of 2000 pounds is used in some cases and the long ton of 2240 pounds in others, while the metric ton of 1000 kilograms represents 2205 avoirdupois pounds. Thousands of quotations are published daily without specifying whether the ton mentioned is long or short. Besides this confusion, there is the gross ore ton of 2688 pounds; the miner's ton varying from 2500 to 3000 pounds; the displacement ton of 35 cubic feet; the shipping ton of 40 cubic feet; the timber ton of 42 cubic feet and the register ton of 100 cubic feet.

Converting gallons to liters is quite a problem, as the wine gallon contains 231 cubic inches and the milk and beer gallon 282 inches, with the corresponding discrepancies in their subdivisions. The barrel for liquids generally holds 31½ gallons, but the refined oil barrel contains 42 and speaking of crude oil 31½. The word "barrel" also is used to designate 196 pounds of flour, 280 lbs. of shelled corn or 200 lbs. of pork. The legal weight per gallon of kerosene, castor oil, honey and other products varies with the states.

Further confusion is added by the division and subdivision of the yard into feet and inches; the pound into ounces, drams, pennyweights, scruples and grains; the bushel into pecks, quarts and pints and the gallon into quarts, pints and gills. This conglomeration of divisions and subdivisions, compared to the simplicity of the metric system, equals the confusion of pounds sterling, shillings and pence compared with dollars and cents, but only increasing the inconvenience a thousand times.

The weight or cubic contents are seldom mentioned speaking of crates, boxes, baskets and barrels as containers for fruits and vegetables; the capacity varies with the states and the products, and the quotations appearing daily in the trade publications mean nothing to the uninitiated buyer. California, Texas and Florida fruits are sold in containers differing materially in capacity and net weight.

This confusion and complication in the system of weights and measures represents a serious handicap for the full development of inter-American commerce, and the disadvantages increased through the practice of quoting prices FOB American port, granting short terms, using frequently domestic packing, handling correspondence in English and employing travelling representatives who often do not speak the language of the country they visit or only have a smattering of

it, insufficient for demonstration and selling purposes.

I am a firm believer in the effectiveness of satisfactory trade relations as a basis for the promotion of good will and friendship between peoples, but in all truth and justice believe also that no intercourse can be fully developed when it is surrounded by difficulties and made the privilege of a few traders skilled in deciphering complicated quotations. The plainer and simpler inter-American trade becomes the more it will grow and penetrate to the remotest corners of the continent.

This has undoubtedly been the policy of the largest mail order houses in the United States, as the determining factor in their success consists in the incredible facilities which they grant to every customer, describing each article in such a manner that they can place the order and figure the exact cost in a few minutes. The same principles, applied to inter-American trade would produce identical results for all exporters.

The solution consists in adopting the universal system of weights and measures used by clients and competitors alike, which is admirable in its simplicity and will eventually constitute a blessing in the domestic and foreign trade of the United States. By making the change gradually and wisely, immediately in some cases, allowing three, five or ten years in others and teaching the system in the grammar schools all over the country, trade will be made comfortable and satisfactory at home and abroad.

RADIO DEATH-FORCE.

A new investigation of a radio death-force has been made by Prof. R. W. Wood of the Johns Hopkins University and A. L. Loomis of Tuxedo, N. Y., who recently startled the scientific world by the so-called "death whisper" consisting of rays of inaudible sound waves. Their new results have been obtained in a quite different field. They arranged two metal plates a couple of inches apart, and connected them with an electrical oscillator like the ones used in radio sending sets but much smaller. This drives into the plates an intense electric current, alternating at the rate of approximately one hundred million times a second, and giving rise to extremely short radio waves, about three meters long. A mouse placed between the plates, though not touching either one of them, was killed by the intense electromagnetic field. It died in about half a minute, and its blood was found to be all coagulated in its veins. A test tube containing several insects was next tried. The insects were likewise quickly killed, and their bodies became dry and brittle. Professor Wood stated that the experiments were begun only a few days ago, and that the near future is likely to bring some startling results, but he pointed out emphatically that a devastating death-ray to kill at great distances is not to be looked for from this apparatus.—Science News-Letter.

A MODEL TO SHOW THE OPTICAL PRINCIPLES OF THE EYE.

By L. R. Ingersoll,

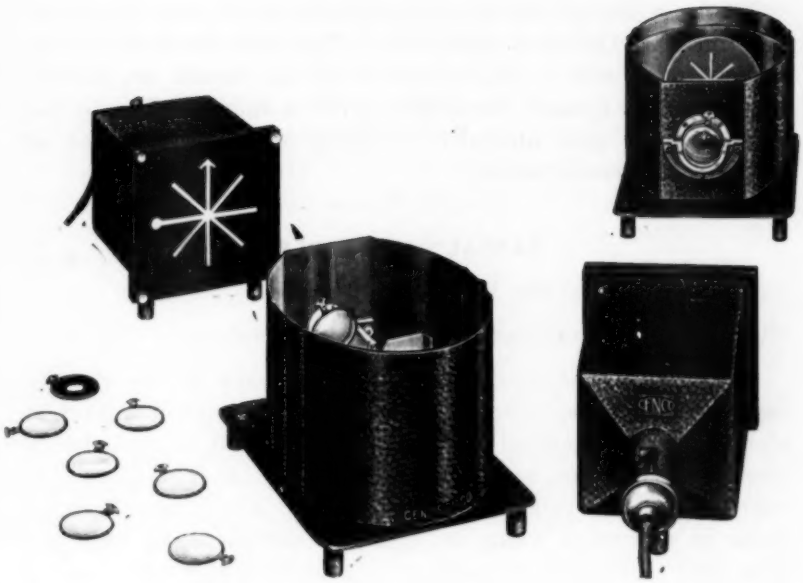
Professor of Physics, University of Wisconsin, Madison.

In view of the importance of the subject it seems a little strange that one finds so seldom in our laboratories a model to illustrate and permit the student to experiment with the optical principles of vision—this too in an age when we have models of everything else from differentials to radio waves. In looking into the situation some time ago the writer concluded that perhaps this lack arose from the fact that the few existing models were cumbersome, required, in general, a dark room for their operation, and withal did not, as a rule, even remotely resemble the human eye.

To meet these objections a model was devised for the study of the optics of vision, simple and compact, usable even in a well-lighted room, and resembling the eye at least enough to arouse the interest of the student and make him realize that he is working with an *eye* and not merely a heterogeneous collection of lenses and similar paraphernalia. It shows the optical principles not only of the normal eye but also of one which is far- or near-sighted or astigmatic. The correction of these defects by eyeglass lenses, the use of the simple magnifying glass, etc., may also be effectively studied and the demonstrations afforded are both simple and striking. The model, of which a few copies have been made, has awakened the interest of those who have seen it to such an extent that its description seems worth while.

The illustration gives a good idea of the model as well as of the object or source of light. It will be noted that the model has, in horizontal section, the general shape of an eyeball, but that the walls are vertical. This last point has a several-fold advantage, for, besides promoting simplicity of construction and operation it allows quite a number of students to observe the phenomena at the same time—or for that matter projection is possible—and at the same time shields the inside from extraneous light to such an extent that no darkening of the room is necessary. The body of the model is water-tight and filled with water to take the place of the humors of the eye.

Light from the object—an illuminated eight-armed cross—is refracted at the "cornea" and "crystalline lens" and falls on the "retina," where a sharp image is formed. This retina



is a curved sheet of metal with white face, which may be slid into grooves in any one of three positions, thus effectively giving for study an eyeball of normal length, a short eyeball, corresponding to a far-sighted eye, and a long eyeball or near-sighted eye.

Accommodation is studied by observing that the crystalline lens has to be changed for one of shorter focus when the object is brought nearer. Near- and far-sightedness are produced by shifting the retina as mentioned above, and corrected by bringing the image again to sharpness by placing a suitable eyeglass lens in front of the cornea. Astigmatism is produced by inserting a cylindrical lens behind the cornea and just inside the model. This gives the sharpening of one of the lines of the cross, which is characteristic of astigmatism: correction is made by placing a suitable cylindrical lens in the holder in front of the cornea and turning it until its axis has the proper direction. Compound defects may be similarly produced and their correction applied, while the action of the simple microscope is effectively demonstrated by introducing a short-focus convex lens in front of the cornea and noting that the eye must accordingly be brought nearer the object, the image on the retina being correspondingly enlarged.

There are also several other phenomena which may be studied but these are the most important. The high school or college student who sees a demonstration of the model or, better, works with it himself, invariably gains a familiarity with the action of the eye, optically speaking, which no amount of reading alone could produce.

PASCAL'S PRINCIPLE.

By Wm. S. Franklin,

Massachusetts Institute of Technology.

One of the most confused sections of many of our physics texts is the section which deals with the pressure of a fluid at rest. The fundamental facts are: (1) A fluid at rest always pushes normally on an exposed area $\triangle a$. (2) The force $\triangle F$ exerted on $\triangle a$ is proportional to $\triangle a$. (3) The force $\triangle F$ is the same in numerical value in whatever direction the area $\triangle a$ may fall. This third proposition is easily derivable from 1 and 2 by considering that the forces exerted on a small portion of the fluid must be balanced.

These facts lead to an important force concept, namely, the conception of hydrostatic pressure. The quotient $\triangle F/\triangle a$ has a definite limiting value which is called the pressure of the fluid at the point where $\triangle a$ is located.

To say that the force $\triangle F$ (the actuai push on $\triangle a$) is the same in numerical value in whatever direction the area $\triangle a$ may face is clear, precise and intelligible; but to say that "the pressure of a fluid is the same in all directions" is nonsense.

The fundamental facts 1, 2 and 3 were first pointed out by Pascal, and in honor (?) of Pascal the attempt is often made to state a so-called "Pascal Principle" by saying that "a fluid at rest transmits pressure equally in all directions." This is not exactly a nonsense statement but it is hopelessly unintelligible. What we are really concerned with is the state of force action in a fluid at rest (in equilibrium), and the term "transmission" certainly suggests dynamical consideration. When you do something to a fluid so as to change the pressure everywhere the transmission of the new condition to the various parts of the fluid is not statics, it is dynamics. If one were interested in the state of force action in a stretched string at rest one could say with a show of profound learning that "the string transmits tension

equally in both directions," but it is certainly simpler to say that the tension of the string must everywhere be the same (gravity assumed to be non-existent). This is the condition of equilibrium of a stretched string which is not acted on by gravity. Similarly the condition of equilibrium of a body of fluid which is not acted on by gravity is that the pressure must be the same throughout the fluid, and this proposition can be derived mathematically from the fundamental facts 1, 2 and 3 as stated in the opening paragraph.

Now if the statement that "a fluid at rest transmits pressure equally in all directions" is intended to mean that the pressure must be the same throughout a body of fluid at rest and not acted on by gravity, then even so it should not be called a principle because a principle in physics is like an axiom in geometry —not to be proven mathematically; whereas the equality of pressure throughout a body of fluid at rest and not acted on by gravity is derivable mathematically as above pointed out.

Speaking of principles in physics, and, in particular, having in mind something which we would wish to name in honor of Pascal, it is perhaps worth while to quote Pascal himself. Speaking of the recognition of principles in physics Pascal says that "Nothing is needed beyond a good sight; but good it must be, for principles are so minute."

Why does a fluid at rest always push normally on an exposed plane area? Half a dozen college texts would have it that "we know a fluid pushes normally on an exposed surface because the shear modulus of a fluid is zero" whereas, when we come to talk about shear modulus (if we ever reach that point in our study) we learn that the shear modulus of a fluid is zero because a fluid at rest always does push normally on an exposed surface!

SHOVEL DIGS OUT SHARKS.

More fossil fishes and sharks are being turned out in a day by a power shovel operating in the region of the west of Cleveland, Ohio, known to geologists as the Big Creek basin, than the patience of old time collectors would bring to light in a whole season. Since lots are being laid out in this section of Cleveland shale, prized by scientists for its fishy relics of a past age, the Cleveland Museum of Natural History has obtained the cooperation of one of the land companies and funds from friends to manipulate a steam shovel. Though Big Creek is only one foot deep, sharks five feet long are caught by the shovel while the bungalows creep closer every day. Many choice fishes, millions of years old, are being saved to science that would otherwise be lost, according to Dr. J. E. Hyde, curator of geology of the Cleveland Museum.—Science News-Letter.

AN INTRODUCTION TO BIOLOGY.

By LYMAN CHILD WOOSTER,

Emporia, Kansas.

Many writers on biology forget that they should write about life and its manifestations, so they discourse very learnedly concerning certain forms of matter which are called plants and animals. They even go so far as to maintain that there is no such entity as life working with energy on matter to make and operate the various living organisms.

The Webster New International Dictionary defines biology as the science of life. "Life," according to this standard dictionary, "is the quality or character which distinguishes an animal or a plant from inorganic or from dead organic bodies, and which is especially manifested by metabolism, growth, reproduction and internal powers of adaptation to environment."

And yet, Doctor T. H. Morgan of Columbia says in his recent authoritative and exhaustive work on The Theory of the Gene: "When all this is given due weight it nevertheless is difficult to resist the fascinating assumption that the gene is constant because it represents an organic chemical entity." Page 310.

Thus we see that a biologist of the standing of Doctor Morgan would turn to chemistry for an explanation of the qualities and powers of living, organic molecules which he terms, genes, each possessing a unit character of a plant or animal.

This is a pure assumption for no chemist believes that living protoplasm, the cell substance, has the same composition as dead protoplasm, he has no idea of the number of kinds of molecules there are in living or dead protoplasm, he finds no chemical difference in the protoplasm of plants and animals nor in the protoplasm of the different species of these organisms, and he would merely say that protoplasm is composed of an unknown number of proteins and that these proteins contain carbon, hydrogen, oxygen, nitrogen, sulfur and sometimes fosforus.

Second, The chemist never found a chemical molecule dividing into two molecules, each like the first, yet genes are said to so divide. He says that such a supposition is absurd in chemistry.

Third, The chemists say that no chemical molecule requires continuous supplies of energy to maintain its qualities, yet all know that living protoplasm dies in all its parts and changes to

some other form of protein when the supplies of energy cease.

Fourth, All chemists say that no chemical molecule varies its qualities in the course of millenniums of time. Limestone laid down twenty million years ago has today the same composition of its molecules as limestone formed yesterday. If the genes are chemical molecules they must likewise be unchangeable and there could be no progress in living things, no evolution.

Fifth, No group of chemical molecules can move in response to sensations or do or not do as they will, yet the amoeba can change its shape, flow in various directions and do or not do as it wills.

It would be far better for all biologists, in presenting the physiology and ecology of living things to treat the organic world as ruled by life, a variable, and quit trying to explain the activities of living things as though these were governed by the laws of physics and chemistry which are as fixed as the laws of the Medes and Persians—for it can not be done.

When all admit that life manages matter through energy, that life is a variable capable of learning by experience, and, in its treatment of matter, must obey the laws of physics and chemistry, the absurdities of biology will be to a large extent removed and life be made supreme in the organic world.

While many of the characteristics of life are known to all who are alive, still it is convenient to know what life is not. We have been told that matter is that which occupies space and has weight. We cannot say that life occupies space for we have never seen its boundaries and so have not measured it. Life certainly does not have weight for careful weighing of bodies before and after death show no loss of weight when all gases are retained and included.

Life is not one of the physical or chemical forces as was once supposed for it is not needed in computing the incoming and outgoing forces of the body. Life is, therefore, not energy, but certainly has the ability to direct the physical and chemical forces in managing the body metabolisms and movements. How it does these things we may not be able to fully explain, but all must admit that life does the work for it is not done when the body is dead.

Life can certainly learn new things, can persist in doing what it will and thus forms habits, and habits persisted in for many generations become instincts. Instincts can grow slowly, feeding on a fringe of habits, otherwise there could be no develop-

ment, no rising to higher levels of existence. Plants and animals show a gradual ascent from the lowest bacteria and blue-green algae to the giant oak and the most gifted human being.

A brief outline study of the growth of life as it acquires new powers or stagnates when satisfied with the possession of old powers may properly serve as a further introduction to biology.

In its beginnings life is found in the protoplasm of a single cell. This tiny body with an average diameter of about one-thousandth of an inch contains several varieties of protoplasm, each with its specific physical characteristics and functions. The chief parts to be mentioned in this introductory study are wall, cytoplasm and chromatin. The powers of these parts are of chief interest and are seven in number. The wall stands guard with the cytoplasm over the ingress of food and oxygen and over the egress of waste materials. The cytoplasm next within fits the food for becoming living protoplasm and causes the oxygen to combine with other foods so as to release needed energy at the temperature of the body. The cytoplasm also superintends the excretion of waste material. Its other powers will be mentioned later.

All living cells tend to divide when they reach a certain size determined by the nature of their activities. The life in chromatin has for its chief powers the holding and transmission of the hereditary qualities of the species to which the cell belongs and very properly manages cell-division, the simplest form of reproduction. The chromatin is scattered through the cytoplasm in bacteria but in other forms of life is concentrated in a denser body called the nucleus.

The wall and cytoplasm receive stimuli from the outside world which result in sensations which are the occasion for movements of the cell under the direction of its life. The movements are that of flowing or are produced by whip-like extensions of the wall.

Different cells must early have made these seven powers function in different ways and through use and disuse of the parts of the cell well marked varieties of cells came into existence in consequence.

The next step in advance came when a cell in dividing did it in such a way that the two daughter cells stayed together. These divided in turn and cohered and so on till sixteen or more cells remained in a group and became mutually helpful. Thus

altruism had its beginning on earth among living things. This resulted soon in division of labor and unions, that were at first temporary, became permanent.

The seven powers were in time each exercised by specific groups of cells to a greater degree than they exercised the other five or six powers and a complex individual of many cells came into being. These cells doing the same kind of work had more opportunities for being mutually helpful so life placed them together in one part of the individual and they became tissues, and in time tissues doing in general like work were combined in organs.

The first organ made was a digestive chamber. The lowest animals to be each provided with a stomach for the digestion of solid or semisolid food were the sponge, the hydras, the sea anemones and the polyps.

Plants never got that far in development, but for the most part manufacture their own food in cells out of certain mineral materials and in sunshine. The fungi and some others are parasites or saprophytes. The pitcher plant has a sort of digestive cavity made from a leaf.

Animals increased their capacity for development very greatly when they gained a permanent stomach. This organ enabled them to capture and digest parts of other animals and also the food prepared by plants. This use of other forms of life for food is the law of the organic world, and custom has limited the application of this law to members of different species. In general, flesh eating animals kill and devour plant eating animals and plant eaters must destroy plants, but there are many exceptions to this rule. Released from the labor of food manufacture, animals devoted their energies to other activities and therefore developed in many different directions through varied use and disuse.

The next advancement came when animals doubled their parts and organs, that is, became two-sided or bi-symmetric. When one organ became diseased or lost, its companion organ could frequently do the work both had done before. This was always the case when one eye, one limb and usually when one gill or one lung was lost.

Bisymmetry was followed very soon by the preparation of internal cavities to be used as workrooms. The animals now were so complex that cells doing the same kind of work were

united so as to form tissues, such as muscle tissue for movement, bony tissue for frame work, skin for protection from outside injury, connective tissue to hold the parts together and nerve tissue to receive sensations and to act upon them so as to unify the activities of the different parts of the animal.

All the different plans of structure used by life from the beginning as shown in the rocks of the crust of the earth, according to the geologist, are still employed by plants and animals. This indicates that only the few advanced to higher levels of structure and activity, while the many transmitted the tendencies to make similar preparations for living to their descendants and these became stay-behinds or standpatters.

This is a very great convenience to the scientist for he can study today in living forms the development of life from the beginning. This is probably due in part to the fact that many environments have also endured through the ages with little change and the occupants had little necessity to change.

Somewhere back in the line of development, possibly among the round worms, a new type of nerve system arose consisting of a dorsal tube with a supporting stiff rod beneath. In the Lancelet this dorsal nerve tube is formed from a ditch invagination of the ectoderm, which was eventually cut away, from the nerve, forming a tube; and a ridge evagination of the alimentary canal on its dorsal side, forming a rod or noto-chord, the forerunner of a backbone.

With nerve tube and noto-chord and ectoderm, entoderm and mesoderm (the wall of the workrooms) as bases for tissue extensions, the classes of vertebrates made their appearance in succession during the geological periods. The fish came in the Devonian, the amphibians in the Carbonic, the reptiles in the Jura-Trias, the birds in the Cretaceous, the mammals in the Tertiary and the primates in the Quaternary. The fish were then as now cold blooded animals and breathed by means of gills; the amphibians, then as now, were cold blooded animals that lived in the water in their youth and breathed by means of gills, absorbed them in their adult life, lived mostly on land and breathed by means of lungs; the reptiles, then as now, were cold blooded land animals with water tendencies and breathed by means of lungs; the birds then as now were warm blooded animals that breathed chiefly by lungs and lived in the air, water and on the land; the mammals at first as now were warm blooded land animals that breathed by means of lungs and

lived in the water and on the land; and the primates are mammals that at first lived much in the trees but lastly enjoyed arboreal and terrestrial life with man making his home anywhere he pleases.

The simple nerve tube of the Lancelet became enlarged into a brain at its front end. This brain became more and more complex as the higher and higher classes of vertebrates appeared and finally in man it became so large and highly organized that this highest of all vertebrates and mammals was easily the ruler of all life on earth.

Another reason for the ascendency of man in the world of life lay in the fact that homo took the best care of his children.

An independent individual results from the division of a single cell as in the amoeba; on the union of two cells forming a zygote as in ninety-nine one-hundredths of all plants and animals, and in the separation of a group of cells by budding as in the freshwater hydra. The cells which unite to form a zygote are known as egg and sperm. In most of the water phyla of the animal kingdom below the vertebrates the zygotes are left to shift for themselves as soon as laid in the water. In the land phyla, especially among the insects, more or less care is exercised in laying the zygotes or fertilized eggs where the young when hatched will get something to eat.

Among the vertebrates there is exercised greater and greater care in providing nourishment for the young on hatching. Birds and mammals surpass all others in this respect. All the mammals, except the very lowest, retain the egg within their bodies till it has hatched and after during the embryonic life of the young. After birth the young are supplied with milk from a milk gland till they are ready in some degree to use the food of the parent.

The vertebrates agree in a general way in structure, the mammals have the same essential parts and organs and the primates agree so closely in their internal anatomy that the ape may be dissected in place of the human cadaver and what is learned will answer for both. As the higher primates assumed more and more the erect position in walking the front limbs were relieved of the part they had taken in locomotion and became the servants of the head. This erect position has been assumed so recently that the body has not fully accommodated itself to this position.

It will be helpful to summarize the powers of life as manifested in each protoplasmic cell and in the development of plants and animals as shown by increasing complexity, more perfect division of labor and better adjustment to the world environment.

Each cell consists of a wall which, with the cytoplasm, regulates absorption of nutriment and oxygen and controls the excretion of waste; of cytoplasm which is the chief part concerned with assimilation, oxidation of food for energy, motion and sensation, and of a nucleus which bears, for the most part, the heredity qualities of life and is the chief agent in cell-division. The chief powers of a cell are, therefore: Absorption, metabolism, excretion, reproduction, irritability, contractibility and automatic power.

During the milleniums of the earth's history life has advanced by some nine stages to the most advanced position represented in man. Various organisms have reached some one of these several stages and then have stopped their major development to adjust themselves to a special environment. The highest organisms such as the primates pass through all these stages in their individual development, somewhat hastily in some cases for their immediate ancestors have made provision for their supplies of nutriment and oxygen. But each organism repeats in some fashion all the stages below the one where it stops. This is the Biogenic Law. Organisms in their ontogeny recapitulate their phylogeny.

STAGES.

I. Zygote—One cell—Amoeba, Paramecium.
II. Morula—A group of sixteen cells—Pandorina (spheroid).
III. Blastula—Many cells forming surface of a hollow sphere if an animal, or arranged in a straight line if a plant—Volvox, an animal; Spirogyra, a plant.
Remark: This is the highest stage reached by plants.
IV. Gastrula—Ectoderm and entoderm, the latter lining a permanent stomach—Hydra, Anemone, Coral polyp.
V. Bisymmetric—Most organs in pairs—Planarian.
VI. Coelomata—One or more work rooms between ectoderm and entoderm lined with mesoderm—Earthworm.
VII. Nerve-tube—Dorsal nerve tube with noto-chord beneath—Lancelet (Amphioxus).
VIII. Simple-brain—Front end of nerve tube enlarged and five-segmented—Frog.
IX. Complex-brain—Front segment of nerve tube with two lobes and lobes much enlarged—Mammals including Man.

It must be remembered that all life is a unity. The stages had their small beginnings in forms of life below.

THE FUNCTION CONCEPT IN GEOMETRY.

By M. O. Tripp,
Wittenberg College.

At the outset it may be well to recall the usual definitions of functionality. One variable y is a function of another variable x, if x and y are so related that when any value is given to the second variable the first is definitely determined, for example:

$$3x+4y-7=0.$$

One variable z is a function of two other variables, x and y, if a relation between the three variables exists of such a nature that when x and y are given z is definitely determined, for example:

$$5x+2y^2-3+7=0.$$

Evidently the idea of function can be extended to any number of variables.

This concept of the dependence of one variable upon one or more variables has for several years played a somewhat important role in mathematical instruction in secondary schools, and no doubt a great improvement would be made if the idea of functionality were more widely used in the class room than at present.

By means of concrete cases taken from the mensuration of plane and solid figures it is possible to make the function concept stand out as a very concrete process. An attempt is made in this article to show the importance of considering the existence of a general functional relation before the exact form of this relationship is determined.

The form of functional relationship in which one variable is made to depend upon a second variable is the simplest one that can be studied. If we seek to obtain the area A of a sector of a circle of definite radius r, it is easy to make the student see that this area depends upon a single variable, the angle $\varnothing$ of the sector. Moreover, it is easy to convince the pupil that this functional relation is one of proportionality, and that in terms of variation we may write the functional relation thus:

$$A=k\varnothing.$$

Naturally the student is desirous of finding a way of determining this constant k, so that the exact functional relationship may be set up. Work of this kind can be taken up advantageously in plane geometry just before proving the usual

theorem for the area of a sector. Thus the study of this general functional relationship would create interest and have considerable propaedeutic value.

Students may also study with advantage the functional relation between the area A and the angle $\varnothing$ of a segment of a given circle. The teacher can readily lead the student to the conclusion that in this case, just as in the case of the sector, the area A may be considered a function of the angle $\varnothing$. But in this case the relation is not one of proportionality. It is not true that if the angle at the center, corresponding to a segment, is doubled that the area will be doubled. Hence the relation

$$A = k\varnothing$$

which was used for the sector cannot be used for the segment.

The method of writing down the formulae of mensuration which the student has learned from arithmetic, such as the area of a circle, and then proceeding to discuss functionality, does not make the appeal that can be made when the exact relationship is unknown to the student. The natural argument of the student is that it is unnecessary to study the functional relation after the exact formula has been obtained. Starting with the exact functional relationship stifles the heuristic spirit of the young student.

In the domain of space geometry there are numerous opportunities for studying functional relations. Before taking up theorems in solid geometry concerning surfaces and volumes the student should be lead to determine what quantities must be known before the surfaces or volumes in question can be computed.

In studying the convex surface of a right circular cone the student should observe that this quantity is fixed just as soon as two of the three quantities, radius of base, altitude, and slant height are determined; and the formulation of the exact functional relation should follow the study of general functional relations. Thus, the first step is to lead up to one of the three relations:

$$C = f_1\ (r,\ h)$$
$$C = f_2\ (r,\ s)$$
$$C = f_3\ (h,\ s),$$

where

C = convex surface,
h = altitude of cone,

s = slant height of cone.

This process corresponds to the formation of a general estimate before starting to put up a structure, or to a rough approximation before making an exact computation. There is great pedagogical advantage in leading the student up gradually to the various formulae, rather than have him accept them as ready made.

The convex surface of the frustum of a right circular cone can be studied in a functional way from several standpoints. It is usual to consider this surface as dependent upon three quantities, the altitude of the frustum and the radii of the two bases. However, these are not the only three quantities that may be used to determine this surface. Students should be encouraged to think out a different triple of quantities such that the surface may be determined when the quantities of the triple are known.

The study of the volume of a tetrahedron furnishes a good exercise in functional relationship. First the general tetrahedron should be used to determine how many quantities must be given before the volume can be computed. Then the regular tetrahedron can be taken up, thus showing the volume as the function of a single quantity. Surfaces of tetrahedra may also be studied in a similar manner.

In these intuitional studies of functional relationships there is great danger that the student will draw a wrong conclusion. For example, if the average high school student were asked how many quantities are necessary to determine the area of a zone of a given sphere he would probably give an incorrect answer.

The determination of the volume of a spherical segment shows a result which at first sight seems different from the ordinary formula, viz.:

$$V = \frac{\pi h}{2}(r_1^2 + r_2^2) + \frac{\pi h^3}{6}.$$

Here V appears to be a function of three variables; but a little reflection shows that in reality V is a function of two variables, since h may be expressed in terms of r, r_1 and r_2. The method of solution by the calculus brings out clearly that V is a function of two variables, the two limits of integration.

The cut and dried methods so commonly applied in mathematical instruction give occasion for the criticism that the

teaching of our subject is a piece of mechanical work, the mere following of rules and formulae. If a study of the methods of thought leading up to rules and formulae is made through considerations of functional relations, then an important pedagogical step has been taken. The writer hopes that these brief notes will offer an incentive to the consideration of functionality from a point of view different from that usually followed.

A NATURE STUDY EXPERIMENT.

By Edith R. Force,
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"Adapting the course of study in natural science to the conditions in the local community" led Okmulgee high school into an interesting experiment—a summer school nature study course.

It proved in no way inferior, and in so many ways superior to the regular course that a brief account of it may encourage others to take advantage of the best time of the year (if there is a "best time") for nature study.

The prearranged plans called for the same number of clock hours as for the year's course, that is 190, with the usual one unit of credit. The time was to be distributed over six or eight weeks, depending upon the rate of progress. A charge fee of $25.00 per pupil was made to cover all expenses. Experience proved, however, there was too little allowance made for transportation unless cars were furnished by the students and instructor.

The day began at 7 a. m. with 30 minutes to an hour for lunch and relaxation, and ended anywhere from 3:30 to 5:30 p. m. This elasticity in the schedule had a great advantage in the adjustment to weather, fatigue, and type of work to be accomplished that day. For example, if the problem was to be the careful, quiet observation of birds, feeding and nesting, there was more time for class discussions, reading and oral or written tests in the field. On the other hand, if the area studied covered more ground, requiring more tramping and collection of specimens it was necessary to have short rest periods and return early to the laboratory.

The individual daily equipment of each student consisted of the all-important lunch and water. The value of an orange or lemon instead of candy, for refreshment, was soon learned.

A pocket notebook, pencils, and a pair of field glasses were essentials. Frequently it is possible to borrow the latter, or the purchase by students or school of the reasonably priced monoculars or binoculars proves quite satisfactory. A variety of pocket field guides, as tree, flower, bird and the like, distributed in the group adds definiteness to the observations. Some small cyanide bottles for insects, muslin sacks for reptiles and medium sized magazines for tree leaves and flowers, (if no vasculum is procurable) string, pocket knives and gum were always found scattered among the group. A minnow bucket, insect nets, "hiking sticks" and larger reference and study books were "car equipment." Preparedness, on the part of the instructor, always added a small pocket hand-lens, a vial of potassium permanganate in solution, a clean, sharp safety-razor blade and gauze. Ants, spiders, scorpions and nettles, poison ivy and poison snake bites require knowledge of prevention and cure at the very outset. Suggested requirements of long sleeves, high collars, sensible shoes, boots or puttees, together with knickers, adds comfort and ease in travel for all.

As during the regular term, the first year course of study required the identification of a minimum number of insects, trees, flowers, fish, and animals including amphibians and reptiles. General knowledge of the essentials of animal, plant and human biology was also required. Comstock's "Field Notes" and the regular state adopted biology textbook was the basis of instruction. The students understood that if only the minimum requirements were completed, of course only an average "C" grade was given. The spirit of achievement was evidenced in the splendid efforts put forth. Adventuring with Nature's problems, in itself, has an appeal to press on—to find the answer, which adds the zest of research to each day. The bigness of the task allures but does not appall, if it is divided into minor problems.

The problem of the class was to help establish the records of wild life in the county. The problems of the individuals varied with the previous preparation and training. All had a common interest in the birds. One of the advanced students added the flora for her problem, another insects, and a third, reptiles. The half year students studied birds and trees. The beginners had the full task. The visitor, a nature-minded tenth grade boy, made valuable contributions to the reptile collection. Of course, although the subject matter was the

same, the class rank determined the standard of type requirements.

In concluding this explanation it is well to mention a few seemingly miscellaneous, minor suggestions, which, however, if they were overlooked could cause considerable dissatisfaction with the summer experiment.

The success of the venture, beyond a doubt, lies in the well planned preparations of the instructor, aided by the goodwill and cooperation of the school administration. For the leader to be fully acquainted with the areas to be visited, the amount of time to be consumed getting there, and the material available for study in that particular locality is a self-evident essential. Most any county will furnish enough habitats and associations for continued variety in the investigations. The long days together call for a kindly, firm understanding with the students as to what is expected in gentlemanly and ladylike field conduct. This strengthens the comrade good-fellowship and enjoyment in the group that builds up a splendid good citizenship. Encouraging the individuals to follow the avenues of their interests, at the same time, helping them to contribute to the information of all, happily combines the spirit of investigation with the working-togetherness of the group.

In weighing the values of this summer school course, they all have seemed very positive. The emphasizing of the results desired by the seven cardinal principles of secondary education were unquestioned. The positive proof that a number of 'teen age young folks can do eight or nine hours of intent, scarcely interrupted, concentrated study—on a rainy day—and then sincerely remark "how fast the time has gone" is a joy in itself. To get "close to nature" in any locality enlarges the appreciation and understanding of that community. The collecting and publishing of scientifically accurate check lists of the wild life, of particularly an unrecorded section of the country, is of inestimable value. In any case, a real contribution to the already known fields is never amiss. Finally, if in any small measure this simple recounting of an experiment tried and found worthy of the effort encourages others in a like venture, it has fulfilled its mission.

"We glorify work, because through work we are free. We work to win, to conquer, to be masters. We work for the joy of working, and because we are free."

LESSON PLANNING IN CHEMISTRY.

By J. A. ERNEST ZIMMERMAN,

Training Instructor and Critic Teacher, State Normal School, Shippensburg, Pa.

The present cry among educators and laymen is "Reorganization." We must have reorganization, but how shall this reorganization take place? Who shall reorganize all the matter to be taught? While there is a great deal of "dead wood" in our textbooks for the average student in chemistry, it does not seem to the author that it is the only cause for discussion and reorganization. It appears that reorganization in methods of teaching the subject should also be made at the present time so that both reorganization of subject-matter and of method may go hand in hand and aid our secondary students in getting a firmer grasp and better idea of the science, what it has done and is doing for humanity.

There are a few teachers of the subject in our schools to-day who have caught the modern spirit of impressing the students studying the problem of chemistry, but there are a greater number, who do not have the idea of interpreting and explaining to the minds of these students through teaching the possibilities and avenues that are opened by it. Most of our chemistry teachers have a very thorough grasp of the subject-matter, but they seem to have no method of presenting it. These instructors, for that would be a better name for them, have the old method, formal in aspect, of questioning their pupils so that the same may answer either by a "yes" or a "no". Many questions are of such a nature as to imply the answer, while others are of the type leading to confusion. It is likely that less than one per cent are thought-provoking questions. It is this thought-provoking question that leads students to do things and teaches them the right attitude and respect for gathering materials. Boys and girls of high school age want to know. They are living question marks and where this force is not stimulated it is lost and becomes a blackened heap of what might have been a rich and happy experience to them. Men, standing high in educational work and institutions, have repeatedly told the author and bemoaned the fact that they had not opportunity to study science. This is an age of science and let us give to these young people what rightfully belongs to them.

The author, who has taught chemistry for seven years, has found in his experience that the fault of this lack is due to the

manner in which the classroom work is conducted. In the early stage of the "game" he was unable to arouse the interest that he so much desired, due to the fact that he had not had a proper method of procedure. It was only after a thorough study of planning the second year that the desired results were obtained. On the visitation to other classes and other schools teaching the subject, he was able to analyze similar errors made by him in his classroom and consequently a further reorganization and planning resulted. As a college student he had never heard of lesson planning as it is conducted in our best normal schools and teacher training institutions of the country. He only knew, as many others know, to read over the subject-matter and ask questions on the same, illustrating and explaining wherever he thought it necessary. This resulted in the yes-and-no-type question, the implied answer question and less than one per cent thought-provoking questions. It seems a sad mistake that even our normal school trained people seem to forget the value of planning after they have gone to college and graduated.

With the introduction of the lesson plan, a new era opened and the classes became interested to a much greater extent than ever before. With the development of the lesson plan came new ideas and practices; one of these "Teaching Valence Prior To Balancing Chemical Equations"* was the direct outcome of this reorganization policy and method.

In this reorganization, the outline method for the student is employed, i. e., an outline of the problem is placed on the board of the important facts to be observed in order to save time. All topics are treated from the standpoint of family relationships without letting the pupils know, at the time, that the various elements are members of a distinct class until the time for the study of family relationship arrives. Thus chlorine would be thoroughly studied and outlined by the student; when the family was discussed its members were chosen from the standpoint of similarities and dissimilarities. The following points were stressed from the beginning because they seemed the most prominent in the study of the subject and occurred and re-occurred time after time in related manner. Since repetition results in formation of habits the pupils were taught to look for recurring similarities in the study of each element. They were given this out-

*Journal of Chemical Education, Vol. II, No. 5, May, 1925.

line to which they seemed to adhere, passing it to other classes that selected the subject.

Occurrence: Free or in compound, if in compounds a few to be noted.
Preparation: If in compounds how is it extracted?
Properties: (a) Physical. (b) Chemical.
Compounds: Formed by man.
Use:
With the study of Chlorine it would assume this aspect:
Occurrence: Never uncombined; Salt.
Preparation:
Laboratory method: Treating MnO_2 and NaCl with H_2SO_4, or HCl on an oxidizing agent.
Commercial method: Electrolysing NaCl.
Properties:
Physical; yellowish-green gas (Name from Greek meaning green), heavier than air, penetrating choking odor affects the mucous membrane causing cold, sharp taste, etc.
Chemical; certain elements react with it giving off light and heat, combines readily with most elements forming chlorides, action of bleaching, etc.
Compounds formed: NaCl, $CaOCl_2$, $KClO_3$, chloroform (used in medicine AgCl (used in photography).
Test: $AgNO_3$ forms a *white precipitate* in presence of HNO_3 with any chloride.
Uses: Warfare, dyes, medicines, disinfectants, bleaching (laundries) etc.

The lesson plan for the above problem will assume the following aspect and in planning it all possibilities for the yes-and-no-type question become eliminated:

I. Problem: The study and properties of chlorine.
II. Teacher's Aim: To have pupils realize the importance of this element and to become acquainted with its uses.
III. Topical Outline: Occurrence, preparation (electrolysis). Properties (physical and chemical), bleaching, compounds formed, tests, uses
IV. Materials Needed: Natural specimens containing the element, hydrogen generator, antimony, cloth that is dyed to show the bleaching action of the element.

I—Subject-Matter.	I—Method (Procedure).
A. Chlorine (A colored gas).	A. What form of compounds have been studied until this time? (Gases.) What is a gas? What was one of the gases used during the early part of the war? Why was this gas used? (Answers will vary.) How successful were the contestants with this weapon? How long was it employed as an implement of war? Let us see if we can find out why it was of use to the warring nations, what the important facts were that led to its adoption. (A general interest is always shown at this stage and may be used for further work.)
B. Occurrence.	B. How do we find this gas which is an element, in nature? (Here it is advisable to let them find it in the book and develop their outline.) Why is it not found as we find oxygen and nitrogen in the air? Name some of the materials in which it is found. (Pass specimens through class.) The element is a gas but why do we not find it as such?

C. Preparation: Common table salt, manganese dioxide and sulphuric acid, heated in a hydrogen generator. (Let students suggest the method of preparation.) Hydrochloric acid on an oxidizing agent. Colored cloth, moist and dry. Powdered antimony.	C. We decided that it was not found in the form of a gas nor were its compounds gaseous, how then do you think we can get it in the form of a gas? (Great varieties of answers will result from the work on the gases studied previously.) Let us see if we can prepare the same; what is essential for its preparation? (A compound containing it.) (Let them make use of book and follow preparation.) Prepare four small bottles, in one, hang a dry piece of colored cloth and in the other place a moistened piece of colored cloth, in the third bottle drop powdered antimony, the fourth is placed in the light for inspection as to color.
D. Properties: 1. Physical.	D. 1. What color have you observed the gas to be? Because of its color it is called chlorine coming from the Greek word which means green. Describe the odor for us. Will anyone who has observed the taste tell us what it was? Pour from one bottle to another before the window so they may observe the results. What is peculiar about this gas? Why is it heavier than air? How much heavier than air is it? How could we find out? Let us do so.
2. Chemical (a) Bleaching.	2 (a) Let us look at the calico that was dry and in one of the gas bottles. (Pass through class.) What is the change that has taken place? Do the same with the moist piece. What is the change that has taken place in this piece? Why does chlorine remove the color from one piece and not from the other?
(b) Reaction with antimony	(b) What do you notice as this powdered antimony drops into the bottle of chlorine? Why does it cause light? What are the white fumes that form? What name would you apply to these white fumes? Why?
E. Compounds.	E. Name a few compounds of chlorine, espepecially one that was in an experiment you performed at the beginning of the year. Give a use for chloroform, for chloride of lime. Write some formulas of compounds that contain chlorine. (Many useful compounds will be suggested by the pupils.) What is silver chloride and where is it used? (Photography, this will be discussed under study of silver and its compounds.)
F. Test; silver nitrate in presence of nitric acid produces a white precipitate with any inorganic chloride.	F. In order to discover if there are certain elements or other things present in compounds we employ certain ways to prove this; what name may be and is employed to this way? What way would you devise testing for chlorine so that it can be used without failing? (Add silver nitrate to a chloride and then add nitric acid to test the solubility of the white precipitate formed to show its insolubility.) Write the equation representing this reaction.
G. Uses: 1. Bleaching	G. 1. From the foregoing discussion and study of chlorine what uses could you sug-

gest besides the use of it in warfare? How do laundries employ chlorine? How do they buy it and receive it? How do factories bleach? Some one should be asked for a report on bleaching.

2. Medicine. 2. How is chlorine employed in medicine? Why is it used as a disinfectant? What is a disinfectant?

3. Dyes. 3. How is it employed in dyes? Where is it used in dying goods? Why?

V. Summary: This has always been summarized by letting the students discuss the lesson and bringing up those points that had not been thoroughly understood. In the outline the student is always requested to record the page on which the problem is to be found, so that he may always be able to locate the same when it is wanted for further information or discussion.

A CONCRETE ENERGY CONCEPT,

By Frederick Reed,

Miami University, Oxford, Ohio.

The science of physics deals with relations between matter and energy. To a young student the word matter has a definite meaning based upon definite experiences. The law of conservation of matter if not already a part of his experience, is a principle he apprehends in a very short time.

Energy, however, is a word applied to phenomena of a more baffling order. The pupil has long been familiar with the sensations of light, heat, sound; he has experienced motion of ponderable masses; he has some acquaintance with electrical manifestations of varying kinds. It is now forced upon him that these things (to him they are things, as substantial as any other experiences) possess the inexplicable property of transubstantiation; heat disappearing and movement resulting, in its turn vanishing to give rise to an electric current which may be used to restore heat. The amount of the final heat is always less than the initial quantity, but the docile student is not unwilling to accept that if all losses could be eliminated in some more ideal scheme of things than the god of machines has ordained, that a principle of energy conservation would be apparent.

Energy, then, becomes a blanket term covering the various phenomena mentioned, whose only interconnection seems to be that some of them may disappear to give rise to others. Why they possess this bewildering attainment is not discussed in physics texts.

What is energy? The text, the teacher, and after a little drill the pupils content themselves with answering "The capacity for doing work." As information this is, of course, more or less

accurate; as a definition it has the fault of not defining. Work is what some forms of energy under certain conditions, may accomplish; it is the way energy is sometimes measured. The definition was framed to include that ambiguous possibility called potential energy. It excludes all radiant energy save through a limited range of frequencies, and applies to heat only when its intensity is greater in one place than another.

It follows that for the physicist energy is an abstraction that is sometimes convenient. For the student it becomes only a class name, meaningless in itself. It is not impossible that for some students it is well to let it go at that. A more ambitious teacher who tries to accentuate the reality of his subject, and who realizes that to the young only the concrete is real, must give another answer to the question, "What is energy?"

Motion is the only factor common to all the disguises in which energy appears. Mechanical energy is motion of masses; electrical energy the motion of electrons; radiant energy, of magnetic fields; sound and heat, of molecules; chemical energy, the orbital motion of electrons, (it may be expedient to treat it as potential energy); potential energy is, of course, merely potential motion: the possibility of motion.

Energy changes occur only by the gain and loss of motion. Work is done on an object only by modifying its motion; it can be done only by an object whose initial motion is greater than that of the object acted upon. Where there is motion there also is energy; if the motion is there only potentially, so too is the energy; where there is no motion there is no energy. When energy is transferred from one body to another, motion is the only thing lost by the first and gained by the second. When energy is changed from one form to another, it is merely the transfer of motion from one kind of matter to another: masses or molecules or electrons, or perhaps ether.

If it is to be presented to the student as a thing, as a reality, *energy is motion*; that is all. Not only will such a statement give the topic the definiteness it needs to make a lasting impression on the pupil, but it contains within itself the explanation of energy changes, energy conservation, and the possibility of accomplishing work during the course of energy transformations.

The university-trained physicist will doubtless prefer to retain the concept of energy as a personification of the possibility of exerting a force through a distance. It is easy to measure it that way. There is no reason why he should not do this. But

the job of a teacher is to attach in a short time meanings in young minds to words which only years of experience can really interpret. Definitions are always arbitrary, but the ease with which they are taught blinds many a teacher to their emptiness. That "energy is motion" is a description and an explanation.

SCIENCE COURSES IN SECONDARY SCHOOLS.

REPORT OF THE COMMITTEE ON BIOLOGY.

Presented at the Meeting of the Association of Science Teachers of the Middle States and Maryland, Nov. 27, 1926, at Buffalo, N. Y.

INTRODUCTION.

Our purpose is to consider what are the most important objectives in the present overcrowded curriculum in 10th year biology.

Most of us teachers of biology realize that consideration of the biology of man and of his social environment is too often deferred to the very end of the course or omitted entirely. Indeed, most of our text-books are built upon a sequence which results this way. However, it takes but a brief study of courses in elementary nature study and in junior high school science to see that throughout the country most of the observational and "static" phases of the study of living things about us have been done, and often quite carefully done, before the pupil reaches the 10th year.

For example, evolutionary types of most of the invertebrates and all of the vertebrates have been studied as to structure, function of parts, characteristic habitat, activities, life cycles, economic importance, control and conservation; all the common facts of germination, growth and propagation of plants; the common facts of gardening, forestry, fisheries, leather and textile manufacture; the preparation, storage, transport, adulteration, and sanitary inspection of foods prepared from plant and animal life; the uses of the classes of foods in the human body; and other fundamental considerations of personal health, such as ventilation, exercise, cleanliness, etc.

When we recall, without repeating, the great mass of information already studied by the pupil, increasingly done under skilful guidance of trained teachers, we see that we have here a very potent way of saving time for what we all consider the most important phases of work in 10th year biology. For this is the last opportunity we shall have of discussing with these pupils and guiding their study of those great underlying principles of life, including human life, which must form the basis of their convictions as citizens a few years later.

The great facts of survival through adaptation, and of heredity apply just as truly to the human being as to any other living thing. Therefore, a study of man's social environment must be included in a complete course in biology.

Our recent text-books, such as those of Hodge and Dawson, Hunter, Atwood, Gruenberg, Linville, Peabody and Hunt, and others, provide us with excellent material to put into the hands of pupils to help them in their study of this exceedingly important part of their high school work.

There is no difficulty in introducing this emphasis upon our social environment when taken up in connection with the study of the great life-phenomena of plants and animals. The following suggested units will serve to show how the observational study leads into the economic study and this again into the emphasis upon dynamic human biology which must be the main outcome of our course.

SUGGESTED UNITS IN TENTH YEAR BIOLOGY.

UNIT I *How Living Things Differ from Non-living Things.* Two weeks.

UNIT II *Relation of Plant Life to Sunlight, Water and Soil.* Four weeks.

UNIT III *The Economic and Genetic Aspects of Plants.* Six weeks.

UNIT IV *Interrelation of Plants and Animals.* Three weeks.

UNIT V *Interrelation of Plants, Animals and Man.* Three weeks.

NOTE—Many of the topics in each of these units have been studied by our Tenth Year pupils in the course of their elementary and intermediate school work. Hence our method should consist largely of careful exploration and recall of material here outlined.

UNIT VI *Classification of Plants.* Two weeks or less.

UNIT VII *Classification of Animals.* Two weeks or less.

UNIT VIII *Economic and Genetic Aspects of Animals.* Six weeks.

Exploratory review of

A. *Insects.* Two weeks. Field, laboratory and library work.
   Problem 1. Recognition and Relation to Environment.
      a. Recognition of 10 species.
      b. Characteristic habitats.
      c. Food and methods of feeding.
      d. Sensation and locomotion.
   Problem 2. Structure.
      a. Study parts of each of 10 specimens brought in by pupils —drawings.
      b. Uses of parts.
   Problem 3. Adaptations and Relation to Man.
      a. Life histories—adaptation for survival.
      b. Distribution and classification.
      c. Economic importance: include disease carriers.
      d. Methods of control.

B. *Birds.* Two weeks. Field, laboratory and library work.
   Problem 1. Recognition and Relation to Environment.
      a. Recognition of 20 species.
      b. Characteristic habitats and food.
   Problem 2. Structure.
      a. External structure—color, in relation to natural and sexual selection.
      b. Internal structure.
   Problem 3. Adaptation and Relation to Man.
      a. Economic importance, including poultry industry. Emphasis on selection and crossing of strains.
      b. Adaptation for survival.
         1. Migration habits.
         2. Nesting habits and care of young.
         3. Natural and sexual selection.
      c. Classification.

C. *Mammals.* Field, laboratory and library work.
   Problem 1. Recognition and Relation to Environment.
      a. Recognition of 10 representative species of quadrupeds.
      b. Characteristic habitats and food.
   Problem 2. How do we use Mammals?
      a. Economic importance of each of the 10 species.
         Include: Dairying Furs

Dairy products Meat packing and its
Leather and wool. products.
Labor, etc.

Emphasis on

1. Sanitary oversight of these industries by government,—local, state, national.
2. Selection and crossing of strains.

b. Life history and adaptation for survival.

1. Migration habits.
2. Care of young.
3. Natural and sexual selection.

c. Classification and genetics.

d. Behavior, as expression of superior nervous system.

Problem 3. How is Man like other Mammals in Structure? In Behavior? How Different?

a. Structure, external and internal, of a common mammal, —specimens and charts.

b. Comparative study of forearms and hands to show adaptation,—mole, bat, cat, cow, horse, man; and of skulls to show increasing development of brain, including human,—relation of length of jaw to length of braincase of each.

UNIT IX The Biology of Man. Twelve weeks.

Problem 1. Man's structure as compared with that of other mammals.

Problem 2. Man's physiological activities as compared with those of other ammmals.

Problem 3. Heredity and variation: Surveys and chart records.

1 A study by each member of class of the family hereditary source of each of

a. 10 or 12 easily recognized external physical variations, such as stature, hair color, eye color, wink, nose line, ear shape, teeth, chin, hand clasp, finger length, nails, foot print angle, voice, etc.

b. 3 or 4 internal physical variations such as pulse rate, blush, anaphylaxis, etc.

c. 10 or 12 mental traits such as excitability; neatness; humor, good taste in dress, recreations, friends, reading, and stories; promptness; orderliness; industry; thrift; hospitality, etc.

CHART I. My Heredity Score Sheet.

Pupil	F.	M.	F. F.	F. M.	M. F.	M. M.
List traits here						

2 A survey of the class, section by section, to prove the truth or falsity of the statement that "Cities are centres of depopulation rather than centres of population," by recording the number of "sibs" in this and the two preceding generations in the family of each pupil:

Chart I is of great interest to the individual pupil but cannot be well summarised for the section and class. Chart II, however, is of most value when so summarized. This can be done most readily by placing the table given here on the blackboard, but spreading the digits apart sufficiently to mark off a column for each section under each digit. Then by asking for a show of hands in each section for every number of children listed in the table, these entries can be quickly made by sections, and the totals added when complete. The same procedure is followed in summarizing Charts III and IV.

CHART II. Number of Sisters and Brothers ("Sibs")

	1	2	3	4	5	6	7	8	9	10	11	12	Total
Pupil													
F.													
M.													
F. F.													
F. M.													
M. F.													
M. M.													

3 A survey of birth-place, city or country, of each pupil, and that of each parent and grandparent:

CHART III. Birthplace.

	Country	City (above 10,000)
Pupil		
F.		
M.		
F. F.		
F. M.		
M. F.		
M. M.		

4 A survey for the study of longevity,—age at death of ancestors.

CHART IV. Which of my ancestors were long lived?

	30	40	50	60	70	80	90	100
F.								
M.								
F. F.								
F. M.								
M. F.								
M. M.								

Problem 4. What Factors Affect our Survival and Progress?

a. Our inherited physical traits.

b. Our inherited mental traits.

c. Our reaction to our social environment—co-operation in:

1 The Home. "An average of one divorce to every seven marriages in the United States." Are children of broken homes handicapped in their chances for survival and progress?

2 The Church, not as an organization, but as the conservator of spiritual values.

3 The School, as a well-rounded life unit.

4 Government-community, state and national. Survey of its manifold functions.

5 Recreation.

6 Work.

The units here suggested comply with the requirements for biology stated in Bulletin No. 26, entitled, "Reorganization of Science in Secondary Schools."

These include:

I. Organization—

Selection and presentation of science work should rest on following:

a. Self-activity is a law of growth.

b. Interest secures attention and makes self-activity possible.

c. Interest, to be sustained, must rest on the perception of the worth-whileness to the individual of the purpose sought.

d. A usable question, problem, project, or topic, involves a purpose, the immediate or future worth of which is recognized by the individual and by the class.

II. Place and Aims—

It is recommended that biology be taught as a Tenth Year subject, and that it be taught not from the point of view of morphology and classification, but from the point of human welfare.

This means that it should contribute to these educational objectives: health, worthy home membership, vocation, citizenship, the worthy use of leisure and ethical character.

These general aims involve specifically:

1 Efficient health instruction;
2 First-hand acquaintance with plants and animals;
3 Structure and function of human body to the end that it may live happily and usefully;
4 Training in accurate observation of life phenomena and to form logical conclusions through the solution of problems and through projects essential to the productive work of agriculture, gardening, etc.;
5 Enrichment of life through aesthetic appeal of living nature;
6 Appreciation of the value of intensive study of plant and animal life as a means through which scientific progress, and so civilization is attained.

III. Sequence and Continuity—

The committee commends elasticity in the content, but it believes that coherence and unity of subject matter are important in any science course, elementary or advanced.

"Study of isolated phenomena may result in a mass of informational material and a sacrifice of the very ideals that science endeavors to inculcate."

IV. Content—

Centralizing ideas or units—

1 The way in which each organism maintains its own life and the life of the species.
2 The interrelations between different organisms and groups.
3 The constant dependence upon and interrelations of living things with the physical world about them.
4 The powers of man to control the habits and relationships of plants and animals to serve his own needs.
5 The powers of man to guide habits and relationships in human life so as to secure progress.

TABLE 1—*SHOWING CONTENT OF THE SEVEN TEXT-BOOKS OF GENERAL BIOLOGY IN MOST GENERAL USE IN THE PUBLIC HIGH SCHOOLS OF THE UNITED STATES (1926).

PORTION OF TEXT-BOOK.

Plant Biology.

Title	1	2	3	4	5	6	7	8	9
Photosynthesis	3	3	4	10	6	1	4	31	4.43
Plant physiology	14	23	7		10	7	3	64	9.14
Osmosis	2	2	10	3	3	2	2	24	3.43
Cells	13	5	6	14	7	8	5	58	8.29

*Numbers 1-7 denote special text books; 8 is the total number of pages devoted to each topic, and 9 is the average number. This is one phase of a study being conducted by John M. Presson, Girard College, Philadelphia, which will be published in the near future.

Bacteria	12	12	13	10	13	2	12	74	10.57
Structure in general	7			1	10	2		20	8.86
Leaves	9	8	18	4	8	3	10	60	8.57
Stems	13	5	18	4	11	3	12	66	9.43
Roots	9	8	9	4	7	5	7	49	7.00
Flowers	13	4	7	13	3	3		43	6.14
Seeds	7	5	17	7	4	8	14	62	8.86
Forestry	27	9	13	9	13	12	10	93	13.29
Fungi	14		6		7	3	5	35	5.00
Soil	16	5	6	3	2	8	3	43	6.14
Classification		5				24	3	32	4.55
Pollination	10	6	10	6	3	12	14	61	8.71
Germination and growth	5	3	8	5	3	2	7	33	4.21
Economics of plants			21	21	6	7	14	69	9.86
Plant breeding	7		1		20	16	3	47	6.71
Algae		2			1	1	7	11	1.57
Reproduction in general	14					20	4	38	5.43
Fruits	11	10	2		9		10	42	6.00
Total	192	129	190	108	146	149	152	1045	150.71

Animal Biology.

Title	1	2	3	4	5	6	7	8	9
Orthoptera	13		13	6	4	2	5	43	6.14
Life activities	9	28	4		5	1	4	51	7.29
Insects in general	24	42	7	9	12	2	15	111	15.86
Lepidoptera	8	1	6	12	1	1	3	32	4.57
Hymenoptera	10		9	10	3		1	33	4.71
Crustacea	12	1	13	8	6	2	12	54	7.71
Piscis	17	2	13	21	10	3	13	79	11.29
Aves	33	5	29	33	24	6	7	137	19.57
Reptilia	9		8			1	5	23	3.29
Mammalia	37		11	15	16	4	8	91	13.00
Protozoa	4		8	7	9	11	9	48	6.86
Diptera	6	8	14	16			3	47	6.71
The simpler metazoa			7		1		4	12	1.71
Annelids	5		11			2	10	28	4.00
Amphibia	20	2	21	16	11	6	8	84	12.00
Porifera	2					1	1	4	0.57
Coelenterata	4					1	5	10	1.43
Echinodermata						2	1	3	0.43
Classification		10				11		21	3.00
Economics of vertebrates	4		11		4	5	5	29	41.4
Economics of invertebrates	3		13		6	35	4	61	8.72
Animal breeding		5	2		6	13		26	3.71
Mollusca	4	2				1	7	14	2.00
Reproduction in general		30		19		14		63	9.00
Total	224	136	200	172	118	124	130	1104	157.71

Human Biology.									
Structure in general	30			15	13	10	14	82	11.71
Foods	22	49	21	48	19	45	15	219	31.29
Digestion	16	8	19	20	20	8	15	106	15.14
Respiration	12	11	10	17	14	17	9	90	12.86
Circulation	18	22	11	25	6	17	16	115	16.43
Nervous System	20	38	17	25	13	42	15	170	24.29
Excretion	6	12	5	3	3	5	6	40	5.71
Stimulants and narcotics	12	2	16	23	22		6	81	11.57
Health	46	37	21	32	38	141	22	337	48.14
Total	182	179	120	208	148	285	118	1240	177.14
Miscellaneous.									
Table of contents	2	4	4	2	2	3	2	19	2.71
Preface	2	3	2	6	4	4	4	25	3.57
Introduction	14	4	4	25	8	12	5	72	10.29
Living and lifeless things, elements and compounds	9	4	20	4	12	1	14	64	9.14
Symbiosis	25				7		8	40	5.71
Heredity	16	20		13		3		52	7.43
Evolution	2	19	21					2	6.00
Physical and chemical changes	1	16			5			22	3.14
Biography			14		7			21	3.00
Conservation	2	1		14		18		35	5.00
Glossary	34				11		13	58	8.29
Appendices	3			16				19	2.71
Index	37	14	10	13	16	11	13	114	16.29
Total	147	85	75	93	72	52	59	586	83.28
Total plant biology	192	129	169	108	146	149	152	1045	150.71
Total animal biology	224	136	200	172	118	124	130	1104	157.71
Total human biology	182	179	120	208	148	285	118	1240	177.14
Total miscellaneous	147	85	75	93	73	52	59	586	83.28
Grand Total	745	529	564	581	484	610	459	3975	568.84

BIBLIOGRAPHY.

The progressive teacher of biology will read such articles as these:

ABBOT, J. F.—*The Teaching of Biology in Secondary Schools*, SCHOOL SCIENCE AND MATHEMATICS, 8:1908.

"The study of biology needs to be adjusted to the great advances that have been made in recent years, or else it will lose its place in the secondary school curriculum."

BIGELOW, M. A.—*Biology in Secondary Schools.* SCHOOL SCIENCE AND MATHEMATICS, 8:1908.

"The course in high school biology should be one based on the conception of biology as a single science using plant and animal life as occasion demands for developing principles."

CALDWELL, O. W., GALLOWAY, T. W., AND NORRIS, H. W.—*Considerations of the Principles that Should Determine Courses in Biology in the Secondary Schools.* SCHOOL SCIENCE AND MATHEMATICS, 9:1909.

One of the first thorough-going studies in the course in high school biology.

CALDWELL, O. W., AND OTHERS.—*The Reorganization of Science in Secondary Schools.* BULLETIN 26, BUREAU OF EDUCATION.

A comprehensive and authoritative treatise on the objectives to be sought in high school biology and on methods for securing these.

COOPRIDER, J. T.—*The Teacher versus Modern Demonstrations in High School Biology.* SCHOOL SCIENCE AND MATHEMATICS, Feb., 1926.

DOWNING, E. R.—*Some Radical Departures in the Teaching of Biology.* SCHOOL SCIENCE AND MATHEMATICS, 24:1924.

A plea for the application of more modern teaching methods to the course in biology, with a revision of its objectives and method of presentation.

FINDLEY, C. W.—*Biology in the Secondary Schools and the Training of Biology Teachers.* Bureau of Publicity, Teachers' College, Columbia University, 1926.

An interesting history of the objectives and method of biology teaching in colleges and secondary schools in America, and a statement of these at present. The influence of Bulletin 26 is pointed out, and a helpful survey of our most recent text-books on biology is given. The second part of the monograph deals with the serious question of inadequate preparation of teachers of biology today.

HUNTER, G. W.—*The Method, Content and Purpose of Biological Science in Secondary Schools of the United States.* SCHOOL SCIENCE AND MATHEMATICS, 25, 8:1925.

A plea for the study of our social, physical and economic as well as our natural environment by means of well organized surveys, planned and executed by the class with the guidance of the teacher, as a means of meeting the great objective of high school biology,—training for citizenship.

HUTSON, P. W.—*The High School Teacher.* Educational Administration and Supervision, 9:1923.

A study of the training of high school teachers in relation to the subjects they teach.

ISENBARGER, JEROME.—*Lecture-Demonstration-Recitation Technique in Biology Teaching.* SCHOOL SCIENCE AND MATHEMATICS, 25:1925.

Efficient technique demands a plan organized about a main purpose for every class exercise.

PAPE, MARY ELIZABETH.—*Some Laboratory Practices in Biology in Secondary Schools.* SCHOOL SCIENCE AND MATHEMATICS, 26:1926.

A study of methods used in teaching biology in secondary schools.

PEARL, R.—*Major Trends of Biology.* Science, 56:1922.

Modern biology deals with organisms as *living things,* not as pickled specimens. All activities of living things, including man, are properly a part of biology. Students of sociology, philosophy, medicine, economics, and many other subjects need to know something about biology.

SMITH, L. K.—*Science Tests: the New Type versus the Old Type.* SCHOOL SCIENCE AND MATHEMATICS, 26:1926.

A comparison of old and new type tests, their advantage and defects.

Experience and observation have shown that better teaching has been accomplished and more interest developed in courses in which objective testing has been done than in those where it is not used. Probably no device has been developed in recent years which so stimulates good teaching and keen interest.

COMMITTEE ON BIOLOGY.

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PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
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The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTIONS.

945. *Virginia Seidensticker, Hyde Park, H. S., Chicago, Ill.*

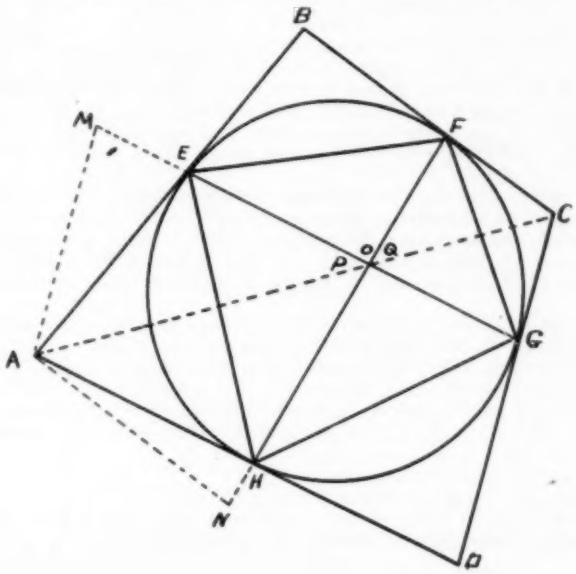
SOLUTIONS OF PROBLEMS.

937. *Proposed by J. F. Howard, San Antonio, Texas.*

If a circumscribed quadrilateral be formed by drawing tangents at the vertices of an inscribed quadrilateral, the diagonals of the two quadrilaterals are concurrent.

Solved by Ma Fu Chiang, Student Manchuria Christian College, Moukden, Manchuria.

Editor. A letter from John C. Witt, the teacher in this school, states that Mr. Chiang is a student in the "Middle School" which corresponds to our High School. The solution is original, and deserves the attention of the readers of the SCHOOL SCIENCE AND MATHEMATICS.



Draw AM parallel to DC, AN parallel to BC. Prolong GE to M, and FH to N. Then, $\angle AEG = \angle DGE$, $\angle M + \angle DGM = 180°$, and $\angle M = \angle AEM$. Hence, AM = AE. Similarly, $\angle N = \angle AHN$, and AN = AH.

Draw the diagonal AC and suppose that it does not pass through O, the intersection of the diagonals of EFGH. Let the two diagonals be cut at the points P and Q. Triangle GQC is similar to triangle MQA. Hence, GC/AE = CQ/AQ, since AM = AE. Triangle ANP is similar to triangle CFP. Hence, CF/AH = CP/AP, since AN = AH. But AE = AH and CG = CF. Then CF/AE = CQ/AQ, and CF/AE = CP/AP. Therefore, CQ/AQ = CP/AP. By principle of composition, CQ: (CQ+AQ) = CP : (CP+AP), or CQ/CA = CP/CA. Hence CQ = CP. This means that AC passes through the point O. In the same manner it can be proved that BD passes through the point O.

946. *Proposed by Philomathe, Montreal, Can.*

Show how to bisect a given arc by means of compasses only.

Solved by Michael Goldberg, Washington, D. C.

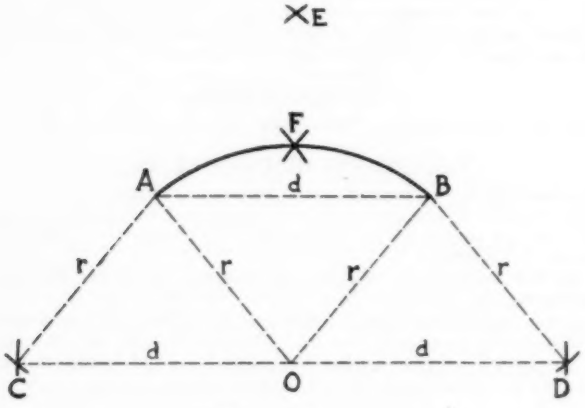


FIGURE 1.

Let O be the center of the circle of which AB is the arc. Draw a circle with center O and radius equal to the chord AB, cutting at C and D the arcs drawn with centers A and B and with radius AO, the radius of the given circle. Using the radius CB, and centers C and D, draw arcs intersecting at E. Then with OE as a radius, and centers C and D, draw arcs intersecting at F, which is the required point. It is not difficult to prove that $(OE)^2 = r^2 + d^2$.

If the center of the arc is not given, it can be found by the method given in my paper on "Compass Constructions" which appeared in School Science and Mathematics, December, 1925. With center A, draw a circle cutting the arc in B and C. Reflect A across BC to D. Then D' the inverse of D with respect to the circle A(B), is the center of the given arc.

Also solved by the *same method* by *George Sergent, Tampico, Mexico.*

947. *Proposed by Norman Anning, Ann Arbor, Mich.*

Show that the following expression is independent of A:

$\cos^2(A-B) + \cos^2(A-C) - 2\cos(A-B)\cos(A-C)\cos(C-B)$.

I. *Solved by P. H. Nygaard, N. Central H. S., Spokane, Wash.*

Let $(A-B) = x$, $(A-C) = y$, then $(C-B) = (x-y)$. Substituting, we get

$\cos^2 x + \cos^2 y - 2\cos x \cos y \cos(x-y)$.

Expanding $\cos(x-y)$, and re-arranging we get,

$\cos^2 x \sin^2 y + \cos^2 y \sin^2 x - 2\cos x \cos y \sin x \sin y$, which may be written

$(\sin x \cos y - \cos x \sin y)^2 = \sin^2(x-y) = \sin^2(C-B)$.

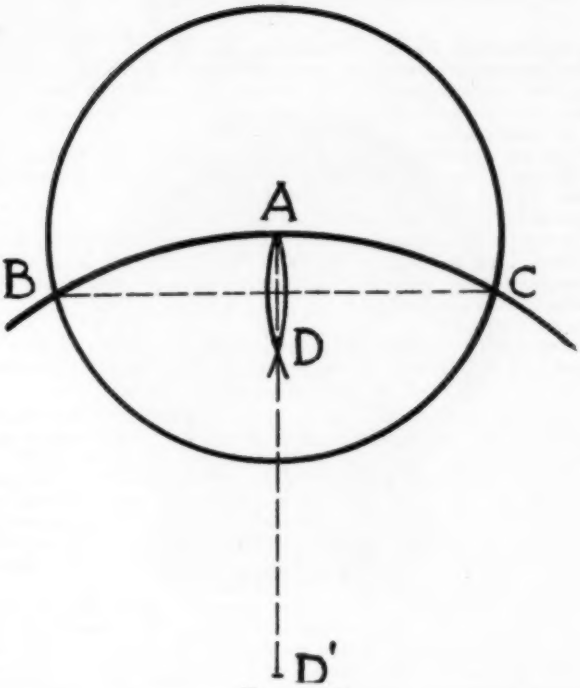


FIGURE 2.

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II. *Solved by Smith D. Turner, Cambridge, Mass.*

Taking the partial derivative of the given expression with respect to A, and making the substitutions for the usual trigonometric identities, it is easily found that partial derivative reduces to zero, hence the original expression is independent of A.

Also solved by *Michael Goldberg, Washington, D. C.; George Sergent, Tampico, Mexico; Paul A. Knedler, Crawford, N. Y.; Henry Ruzicki, Lacey, Wash.;* and *J. Murray Barbour, Aurora, N. Y.*

948. *Proposed by F. A. Caldwell, St. Paul, Minn.*

X is an integer which is not a prime number nor the double of a prime number. Show how to find, in terms of the factors of X^2, the sides of scalene triangles (acute, right, or obtuse) whose sides and areas are integral and whose altitude is X.

Solved by the Proposer.

It was intended to exclude triangles having X for a side but by the wording used failed to do so. In this solution such triangles are excluded.

LEMMAS.

1. If X is an integer which is not a prime number nor the double of a prime number, there can be found *at least* two pairs of integers, a, b and c, d, all unequal and all even or all odd, such that $ab = cd = X^2$.

For, let X be an odd number which is not the square of a prime number. Then X^2 is odd and X^2 (a) and 1 (b) is one pair of unequal odd integers such that $ab = X^2$. And since X is not prime and not the square of a prime number, it is the product of two unequal odd integers (not including X^2, X or 1), which we will call e and f. Then e^2 (c) and f^2 (d) is another pair of unequal odd integers such that $cd = X^2$.

Let X be odd, the square of a prime number. Then X^2 (a) and 1 (b) is one pair of unequal odd integers such that $ab = X^2$. And since X is the square of a prime number it is the product of two equal prime integers which we will call e and f. Then e^3 (c) and e (d) is another pair of unequal odd integers such that $cd = X^2$.

Let X be even and not the double of the square of a prime number. Then X^2 is a multiple of 4 and $X^2/2$ (a) and 2 (b) is one pair of even integers such that $ab = X^2$. And since X is not the double of a prime number nor double the square of a prime number it is the product of 2 and two unequal integers which we will call e and f. Then $2e^2$(c) and $2f^2$(d) is another pair of unequal even integers such that $cd = X^2$.

Let X be even and the double of the square of a prime number. Then X^2 is a multiple of 4 and $X^2/2$ (a) and 2(b) is one pair of unequal even integers such that $ab = X^2$. Since X is even, the double of the square of a prime number it is the product of 2 and two equal integers which we will call e and f. Then $2e^2$ (c) and $2e$(d) is another pair of unequal even integers such that $cd = X^2$.

2. If X be odd, then the difference between any two integers whose product is X^2 is a multiple of 4. For, let $X = a+1$, wherein a is even, and let c and d be any two integers whose product is X^2. We have to show that $c-d$ is a multiple of 4. $X^2 = a^2+2a+1 = cd$. Subtracting 1 from both members of this equation, we have $a+2a = cd-1$. Since a is even, a^2 and $2a$ are multiples of 4. Therefore a^2+2a is a multiple of 4. Therefore $cd-1$ is a multiple of 4. Since X is odd, c and d are odd. Let $c = e+1$ and $d = f+1$, wherein e and f are even. Then $c-d = e-f$, and $cd-1 = ef+e+f$ = a multiple of 4. Since e and f are even, ef is a multiple of 4. Therefore $e+f$ is a multiple of 4. $e+f-2f = e-f = c-d$. Since f is even $2f$ is a multiple of 4, and $e+f$ is a multiple of 4 as shown. Therefore $e+f-2f$ is a multiple of 4. Therefore $c-d$ is a multiple of 4.

3. If a and b are two both-even or both-odd integers, if $a>b$ and if ab is a perfect square, then a triangle having sides $\sqrt{ab}$, $(a-b)/2$ and $(a+b)/2$ will be right angled and have integral sides and $(a+b)/2$ will be its hypotenuse. For, since a and b are both even or both odd $a-b$ and $a+b$ are both even and therefore $(a-b)/2$ and $(a+b)/2$ are both integers: and $\sqrt{ab}$ is an integer by hypothesis. Also

$$ab+\left(\frac{a-b}{2}\right)^2=\left(\frac{a+b}{2}\right)^2.$$

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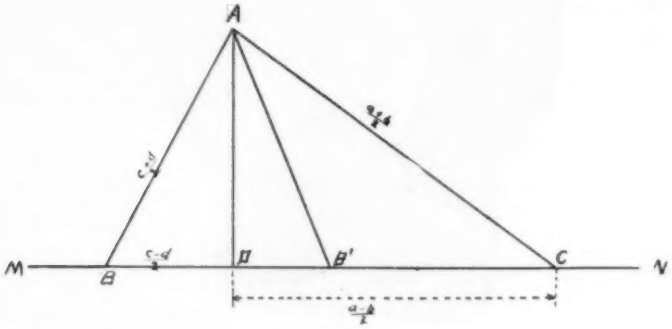
To construct scalene triangles having integral sides and areas and whose altitude is represented by a given number X which is not a prime number nor the double of a prime number proceed as follows:

Case 1. X is an odd number. Draw AD in length equal to X. Draw MN, a line of indefinite length, perpendicular to AD at D. Find two pairs of odd integers (a, b) and (c, d), such that $ab = cd = X^2$; and $a > b$, $a > c$, $c > d$, then $d > b$. On DM take $DB = (c-d)/2$, and on DN take $DC = (a-d)/2$. Draw AB and AC. Then by *Lemma* 3 AB will be equal to $(c+d)/2$, and AC equal to $(a+b)/2$. Then ABC is the required triangle.



First. The altitude is X by construction.

Second. The sides are integral by Lemma 3.

Third. The triangle is scalene. For $(a+b)/2$ and $(c+d)/2$ must be unequal. And BC can be equal neither to AC or AB. For, suppose BC = AB, then $(a-b)/2+(c-d)/2 = (c+d)/2$.

Multiply the members of this equation by 2 and we have: $a-b+c-d = c+d$.

Transposing $c-d$ to the second member of the last equation: $a-d = 2d$.

By Lemma 2. $a-b$ is a multiple of 4. But d is an odd number and therefore 2 is not one of its factors. Therefore $2d$ is not a multiple of 4. Therefore $a-b$ is not equal to $2d$. Therefore BC is not equal to AB.

By a similar proof it may be shown that BC is not equal to AC. Therefore triangle ABC is scalene.

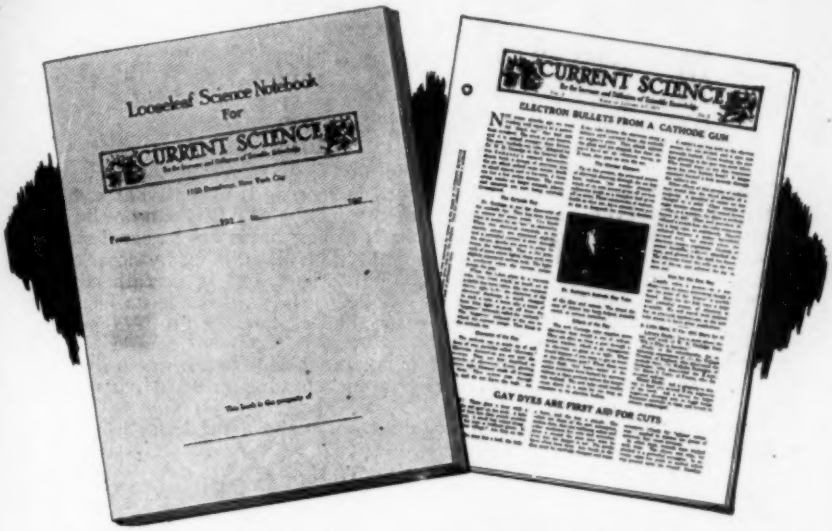
Fourth. The area of ABC is integral. By Lemma 2, $a-b$ and $c-d$ are multiples of 4. Therefore $(a-b)/2$ and $(c-d)/2$ are even numbers. Therefore BD and DC are even. Therefore BD+DC or BC is even. Therefore, since X, the altitude, is integral $BC/2 \times X$, the area of the triangle, is integral.

If on DC, $DB' = (c-d)/2$ is taken, then AB', AC and B'C can be shown to be sides of another triangle which fulfills the conditions of the problem.

For example, given the odd number 45, which is not a prime number, and let it be required to find sides of scalene triangles having integral sides and areas and whose altitude is 45. Make a table of all the pairs of integers (which will necessarily all be odd) whose products are 45^2, as follows:

$$\begin{aligned} 45^2 = 2025 &= 2025 \times 1 \\ &= 675 \times 3 \\ &= 405 \times 5 \\ &= 225 \times 9 \\ &= 135 \times 15 \\ &= 81 \times 25 \\ &= 75 \times 27. \end{aligned}$$

From any two of the above seven pairs of integers may be derived the sides of two triangles fulfilling the conditions of the problem, making 42 triangles in all. From the first and last pairs,



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$$\begin{aligned}
BC &= (2025-1)/2+(75-27)/2 = 1036\\
AC &= (2025+1)/2 \quad 1013\\
AB &= (\ 75+27)/2 \quad 51\\
B'C &= (2025-1)/2-(75-27)/2 = 988\\
AC &= \text{Same as above} = 1013\\
AB' &= \text{Same as AB above} = 51.
\end{aligned}$$

Case II. Wherein X is even. Proceed as in case I, except that a, b, c and d will all be even. In this case triangles ABC and AB′C can be shown to have integral sides by use of Lemma 2. Their areas are integral since the altitude is even and the base integral. The altitude is, by construction, X. In general the triangles will be scalene, but in certain cases, where $a-b = 2d$ or $2c$ and where $c-d = 2b$, they will be isosceles. If $a-b = 2d$, then AB = BC; if $a-b = 2c$, then AB′ = B′C; if $c-d = 2b$, then AC = BC.

Given the even number 120, which is not the double of a prime number. Required to find the sides of scale triangles having integral sides and areas and whose altitude is 120.

Make a table of all pairs of even integers whose products are 120^2 or 14400, as follows:

	Differ-ences		Differ-ences		Differ-ences
7200×2	7198	720×20	700	288×50	238
3600×4	3596	600×24	576	240×60	180
2400×6	2394	480×30	450	200×72	128
1800×8	1792	450×32	418	180×80	100
1440×10	1430	400×36	364	160×90	70
1200×12	1188	360×40	320	150×96	54
900×16	884	300×48	252	14×100	44
800×18	782				

From any two of the above pairs of integers may be derived two triangles fulfilling the conditions of the problem, except:

$$1\ \begin{pmatrix}240\times60\\160\times90\end{pmatrix},\quad 2\ \begin{pmatrix}288\times50\\180\times80\end{pmatrix},\quad 3\ \begin{pmatrix}360\times40\\160\times90\end{pmatrix},\quad 4\ \begin{pmatrix}600\times24\\288\times50\end{pmatrix}.$$

In referring to any two pairs of integers the pair which contains the largest of the four integers involved will be called a and b and the other c and d.

It will be noticed that in the two pairs of integers marked 1, $a-b = 2d$. Therefore triangle ABC is isosceles, and AB = BC.

In the two pairs marked 2, $c-d = 2b$. Therefore ABC is isosceles, and BC = AC.

In the pairs marked 3 and 4, $a-b = 2c$. Therefore AB′C is isosceles, and AB′ = B′C.

This will make 4 triangles out of 462 which will not be scalene.

949. *Proposed by Daniel Kreth, Wellman, Iowa.*

Given sinC = 12/13, the difference of the sides, including that angle, equal to 45, and the radius of the inscribed circle equal to 75, to construct the triangle and calculate its sides.

Solved by George Sergent, Tampico, Mexico.

Construction. Draw a right triangle BDE, in which the sides of the right angle are $BD = a-b = 45$, and $DE = 2r = 150$.

The Perpendicular bisector of DE is a locus of I, the center of the inscribed circle. The other locus is the arc constructed on BE as a chord and containing the angle $90°-C/2$. With their intersection I as a center, and $r = 75$, as a radius, draw the incircle. Draw EI, the prolongation of which determines A on BD produced. From A and B draw to circle I tangents intersecting at C. The ABC is the required triangle.

Computation of sides. First Method.

$$\tan C/2 = \sin C/(1+\cos C) = 2/3. \tag{1}$$

$$\tan C/2 = IG/CG = r/[1/2(a+b-c)]. \tag{2}$$

Knowing that $(a-b) = 45$, we get, from (1) and (2), $c = 2a-270$. The perimeter of the triangle is $(4a-315)$. The two formulas for the area of the triangle, $K = rs$, and $K = (ab \sin C)/2$, give the equation

A Graphic Analysis
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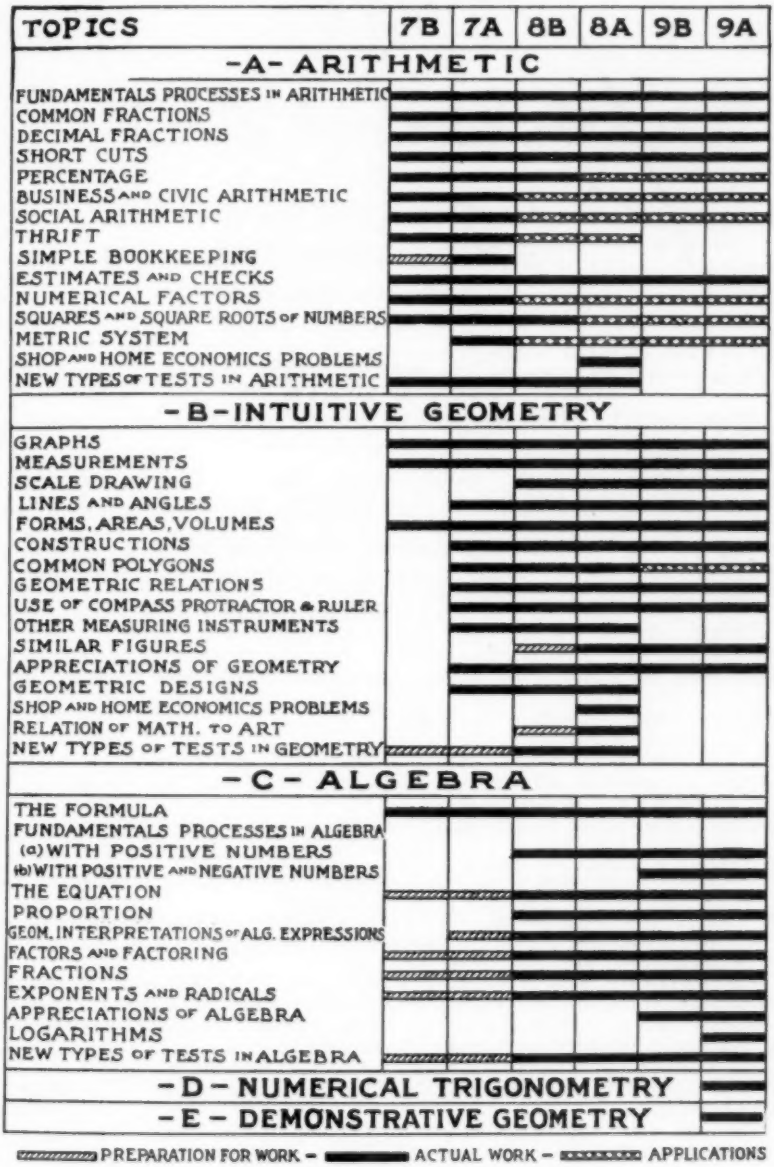
Marie Gugle



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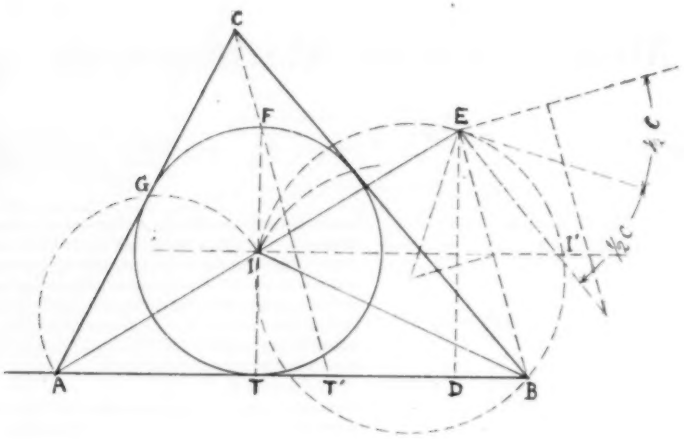

$$75(4a-315)/2 = 12a\,(a-45)/26.$$

Solving the quadratic we get $a = 277.9$, hence $b = 232.9$, and $c = 285.8$.

Second method. Given $\tan\frac{1}{2}(A-B)/\tan\frac{1}{2}(A+B) = (a-b)/(a+b)$ to determine $\tan\frac{1}{2}(A-B)$. In any triangle ABC, we have the relation

$$2h_c \sin(A-B) = (m-n)\cos(A-B) = (m-n)\cos C,$$

m and n being the segments determined by the altitude h_c on AB (m, adjacent to side a; n, adjacent to side b). Applied to triangle AIB, this formula becomes, by substitution,

$$150\sin\tfrac{1}{2}(A-B) - 45\cos\tfrac{1}{2}(A-B) = 45\cos(90+\tfrac{1}{2}C).$$

Expressing the sine and the cosine of one-half the difference of A and B in terms of $\tan\frac{1}{2}(A-B) = x$, we get

$$\frac{100x^2}{1+x^2} - \frac{60x}{1+x^2} + \frac{9}{1+x^2} = \frac{36}{13}$$

Solving this equation we get

$$x = \tan\tfrac{1}{2}(A-B) = \frac{195-3\sqrt{1381}}{632}.$$

Hence (a+b) is easily found to be 510.8. Knowing $(a-b)$, the values of a and b may be found. Since, according to the conditions given, $c = a+b-3r$, we may easily find the value of c.

Also solved by *Michael Goldberg, Washington, D. C.; Smith D. Turner, Cambridge, Mass.; W. R. Warne, Minneapolis, Minn.;* and the *Proposer.*

Editor. This problem is given as an exercise in "College Geometry," by Nathan Altshiller-Court, page 81, exercise 20. A hint is given there to its solution.

950. *Proposed by Nathan Altshiller-Court, Norman, Okla.* For *High School Pupils.*

Through two opposite vertices of a given parallelogram two lines are drawn meeting the sides in four points which determine four lines. Prove that two of these lines are parallel, and two meet in a point collinear with the other two vertices.

I. *Solved by R. L. Harrison, Culver Military Academy, Culver, Ind.*

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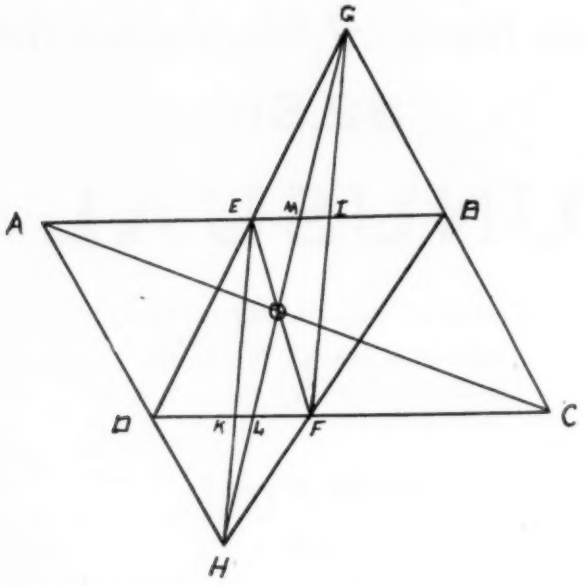

I. To prove EH parallel to GF.

$\triangle HDF \sim \triangle HAB.$
$\triangle AED \sim \triangle GDC.$
$\triangle BFC \sim \triangle HDF.$
$\triangle HAB \sim \triangle BFC.$
$\angle A = \angle C.$
$AD : AE = GC : DC.$
$AH : AB = BC : FC.$
$AE \cdot GC = AD \cdot DC.$
$AH \cdot FC = AB \cdot BC.$
$DC = AB.$
$AD = BC.$
$AE \cdot GC = AH \cdot FC.$
$AE : FC = AH : GC$
$\triangle AEH \sim \triangle GFC.$
$\angle GFC = \angle AEH.$
$\angle AEH = \angle EKC.$
$\angle EKC = \angle GFC.$
$EH \parallel GF.$

II. To prove that EF, GH, and AC are concurrent.

$\angle CLO = \angle AMO.$
$\triangle OLF \sim \triangle EMO.$
$MO : OL = EO : OF.$
$\triangle EOH \sim \triangle GOF.$
$EO : OF = OH : OG.$
$OH : OG = MO : OL.$
$(OH + MO) : MO = (OG + OL) : OL.$
$MH : MO = GL : OL.$
$MH : GL = MO : OL.$
$\triangle AMH \sim \triangle GLC.$
$MH : GL = AM : L.$
$\triangle AOM \sim \triangle COL.$
$\angle AOM = \angle COL.$
ML is a straight line.
AC is a straight line.
The lines EF, GH, and AC are concurrent.

II. *Solved by George Sergent, Tampico, Mexico.*

We can prove the first part of the theorem by proving $\triangle DEG$ similar to $\triangle BHF$. $\angle D = \angle B$. $\angle DAE = \angle BFA$. Hence, $\triangle DEA$ is similar to $\triangle BAF$, and $DE/DA = BA/BF$. Therefore, $DE \cdot BF = DA \cdot BA$ (constant). In the same way, we can prove $\triangle DCG$ is similar to $\triangle BHC$, and $DG \cdot BH = DC \cdot BC$ (constant). Since $DA \cdot BA = DC \cdot BC$, it follows that $DE \cdot BF = DG \cdot BH$. Hence, $DE/DG = BH/BF$, which shows that $\triangle DEG$ is similar to $\triangle BHF$. Therefore, EG is parallel to HF.

The sides of the triangles DEG and BHF being parallel and running in opposite directions, the two triangles are inversely homothetic. The fundamental theorem for homothetic triangles is: *"The lines joining the homologous points of two homothetic figures are concurrent."* Therefore GF and EH intersect on DB, the diagonal of the parallelogram.

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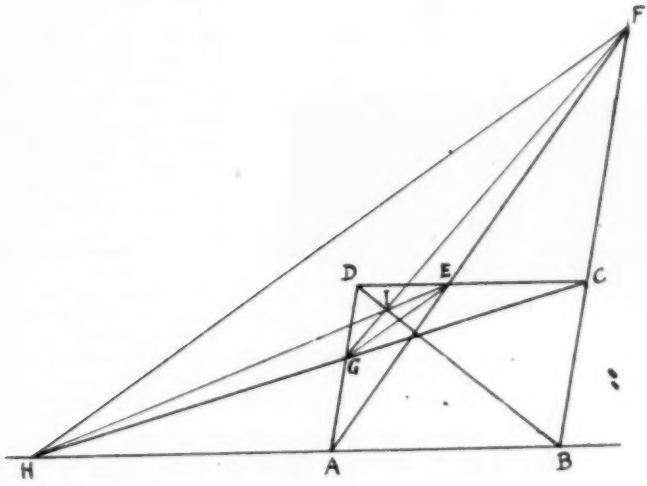

III. *Solved by the Proposer.*

Let ABCD be the given parallelogram; E, H, the points of intersection of the sides CD, CB with the line AEH through A, and F, G the points of intersection of the sides AD, AB with the line CFG through C.

To prove that the lines EF, GH are parallel, observe that the two triads of points EAH, FCG determine a Pascal hexagon HCEFAG, hence the three points (HC, FA), (CE, AG), (EF, GH) are collinear, and since the first two are at infinity, by assumption, the third point is also at infinity.

Again ECHFAG is a Pascal hexagon, hence the three points D = (EC, FA), B = (CH, AG), and (HF, GE) are collinear.

Also solved by *Bessie B. Green, Wichita, Kansas.*

PROBLEMS FOR SOLUTION

961. *Proposed by Orville Barcus, Columbus, Ohio.*

Show that the three numbers are divisible by the same number, $21,556,130^{16}+1$; $21,556,127^{16}+1$; $14,370,753^{16}+1$.

962. *Proposed by Michael Goldberg, Washington, D. C.*

Construct the maximum equilateral triangle through three given points.

963. *Proposed by J. Murray Barbour, Aurora, N. Y.*

If a number, of which only the last n digits are given, is known to be exactly divisible by a given number (or is divisible with a remainder), it is always possible to obtain the last n digits of the quotient by dividing backward—from the unit's digit to the left.

964. *Proposed by Nathan Altshiller-Court, Norman, Okla.*

The lines joining a given point P to the ends of a variable diameter of a given circle, center O, meet the circle again in the points, M, N. Prove that the locus of the center of the circle PMN is a straight line perpendicular to PO.

965. *For High School Pupils. Proposed by J. F. Howard, San Antonio, Tex.*

Standing at a certain distance from a well, I observed a man drop a stone into the well. The man dropping the stone, heard it strike the bottom one second sooner than I did, and the sound of the stone striking the bottom reached my ear in one-half the time that it took the stone to fall to the bottom. Find the depth of the well.

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QUESTIONS AND PROBLEMS FOR SOLUTION AND DISCUSSION.

484. *Proposed by Norman Anning, Department of Mathematics, Ann Arbor, Mich.*

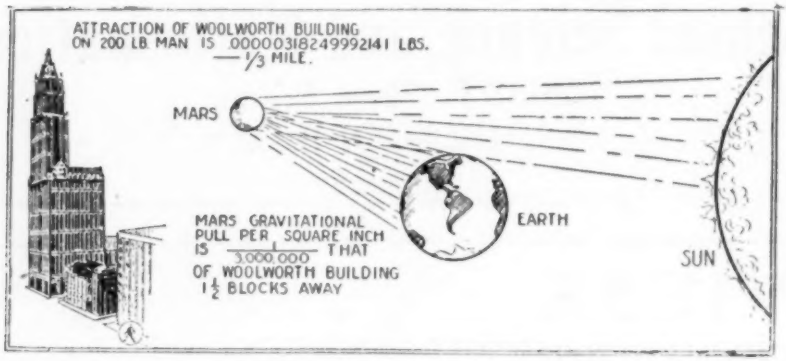
Dear Sir:

The enclosed may be of interest to you for your department of S. S. & M. In the present form it was passed around at a luncheon of our Mathematics Club. You may alter it as you wish if it is of any use to you.

The words "in pounds per square inch" are correctly quoted from the article although they do not show in the extract.

Sincerely yours,

NORMAN ANNING.



What is this mysterious influence which the stars hold in store for us? Is it gravity? No—for the gravitational pull of the Woolworth Building on man is considerably greater than that exerted by any of the planets. It cannot be light because the sun's rays are reflected from the planets. If it is psychic, then it holds for only those who believe in astrology, who believe in the ridiculously super-natural. Of course everything super-natural is not ridiculous. SCIENCE & INVENTION Magazine (Oct., 1926) is willing to be shown that astrology is a science.

Joseph H. Kraus, an editor of a popular monthly magazine engaged in proving that astrology is folly, computes in pounds per square inch the attraction of a building of undeterminable mass on a man of undeterminable area CORRECT TO 12 SIGNIFICANT FIGURES.

QUESTION 484.

QUERY: Has any physical magnitude been measured with an accuracy equivalent to 10 significant figures in decimal notation? (The ephemeris gives the length of the tropical year 1926 as 365.2421972 days.)

[It will be interesting to readers of SCHOOL SCIENCE AND MATHEMATICS to compute this attraction and show principal steps in the calculation.]

485-486. *Proposed by Virginia Seidensticker, Hyde Park High School, 1926.*

A suggestion has been introduced to our County Board that a Botanical Garden be incorporated into the Forest Preserve, so that our local flora

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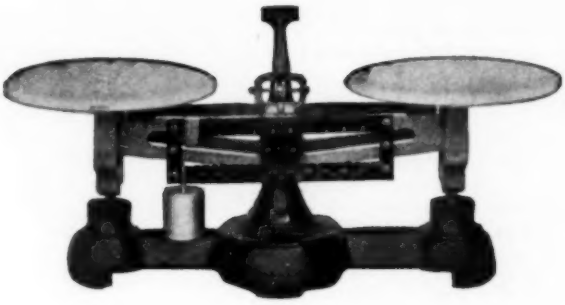

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can be preserved, and also in order that botanical material can be propagated and made available for study purposes.

If not too much trouble I would enjoy having you discuss the topic—

Question 485. Would it be a good thing to have a Botanical Garden in Chicago?

Question 486. Would the garden be a success and reasons?

SOLUTIONS AND ANSWERS.

480. *Proposed by J. C. Packard, Brookline, Mass.*

Does it require more or less work on the part of the hoisting engine to carry a man up a moving incline when he is walking up the stairs while the treads are moving, than when he is standing still?

Solution by Smith D. Turner, Cambridge, Mass.

Answer: It would require less work. The engine would work at the same rate (power) but for a less time.

More specifically:

With the man walking as the stairs move:

$$\text{Power} = WV_s$$
$$\text{Work} = WhV_s$$
$$\overline{V_s + V_m}$$

When the man is standing still:

$$\text{Power} = WV_s$$
$$\text{Work} = Wh$$

Where h = height of stairway.
W = weight of man.
V_s = Vertical component of stairway velocity.
V_m = Vertical component of man's velocity on stationary stairs.

482. An Apology by the Editor of This Department.

Inadvertently, the examination paper on **Botany, 1906,** was omitted from the statement of this question on page 1004 of SCHOOL SCIENCE AND MATHEMATICS, December, 1926.

Obviously, the comparison asked could not be made.

This examination paper will be published in an early number.

[Franklin T. Jones.]

LOWEST AIR TEMPERATURE EVER RECORDED.

The lowest air temperature ever recorded near the earth's surface is 90 degrees below zero Fahrenheit; this extremely low temperature occurred February 5 and 7, 1892, at Verkhoyansk, Siberia, about 200 miles inland from the mouth of the Lena River. Due to the great land masses of the northern hemisphere, especially that of Eurasia, this northern pole of cold is far from the North Pole. This region is supposed to be colder in January than the North Pole itself. It has the lowest mean annual temperature of any place in which trust-worthy temperature records have been kept. Its mean temperature for the month of January is about 60 degrees below zero Fahrenheit. Temperatures even lower than those here quoted have been recorded in the free air aloft by means of balloons carrying self-registering thermometers. The lowest natural air temperature ever recorded in the upper air is 133 degrees below zero Fahrenheit; this was recorded with a registering thermometer attached to a sounding balloon sent up from Batavia, Java, in November, 1913. The exact height at which this temperature was recorded is unknown, but it is believed to be about six or eight miles above the earth's surface.
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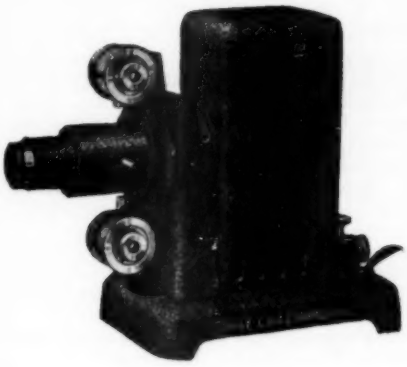

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ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, December, Brooklyn Botanic Garden at Prince and Lemon Sts., Lancaster, Pa., $7.00 a year, 75 cents a single copy. A Biologic and Phylogenetic Study of the Stromatic Sphaeriales, Lewis E. Wehmeyer. Studies on Aster Yellows, L. O. Kunkel. A Physiological Study of the Effect of Light of Various Ranges of Wave Length on the Growth of Plants, Henry William Popp. Seed Germination in the Gray Birch, Betula Populifolia, Freeman Weiss. Factors Influencing the Equilibrium Known as the Isoelectic Point of Plant Tissue, W. J. Youden and F. E. Denny.

Journal of Chemical Education, January, 343 State St., Rochester, New York, $2.00 a year, 35 cents a copy. Photography as a Recording Medium for Scientific Work. Part I, G. E. Matthews and J. I. Crabtree, Research Laboratories, Eastman Kodak Co., Rochester, N. Y. John Dalton, H. F. Coward, Mines Research Laboratories, Sheffield, England. Atomic Hydrogen Flames, Guy Bartlett, General Electric Co., Schenectady, N. Y. A Study of Pupil Errors in Chemistry, Julia C. Bennett, East High School, Cleveland, Ohio. What Sort of Chemistry Should be Taught in the High School? Walter M. Jackson, Wilcox County High School, Camden, Alabama.

The National Geographic Magazine, January, Washington, D. C., $3.50 a year, 50 cents a copy. Jamaica, the Isle of Many Rivers, John Oliver LaGorce. Life on a Coral Reef, W. H. Longley. The Columbus of the Pacific, J. R. Hildebrand.

Scientific American, January, New York, $4.00 a year, 35 cents a copy. The Meaning of the Brain, Professor G. Elliot Smith, University of London. Science Turns Detective, Captain Edward C. Crossman. Applying New "Yardsticks" to Automobiles, Charles F. Kettering. The Threatened Extinction of Some of Our American Game and the Valiant Fight that is Being Made to Save the Remnant, J. Bernard Walker.

Scientific Monthly, January, The Science Press, New York, $5.00 a year, 50 cents a copy. Mongolia, The New World, Professor William K. Gregory, American Museum of Natural History. Formation of the Moon and Earth, W. J. R. Emmet, The General Electric Co. The Determination of Sex, Dr. Robert T. Hance, The Rockefeller Institute for Medical Research. The Unnatural History of the Clothes Moth, Professor Harold Sellers Colton, University of Pennsylvania. The Discovery of Anesthesia, Dr. C. A. H. Smith. Our American Forests, their Past, Present and Future, Dr. Raymond J. Pool, University of Nebraska.

Torreya, November-December, 1926, 8 West King St., Lancaster, Pa., $1.00 a year, 30 cents a copy. Botany of the Montana Rockies, J. E. Kirkwood. An Alga From the Eocene of Colorado, T. D. A. Cockerell.

BOOKS RECEIVED.

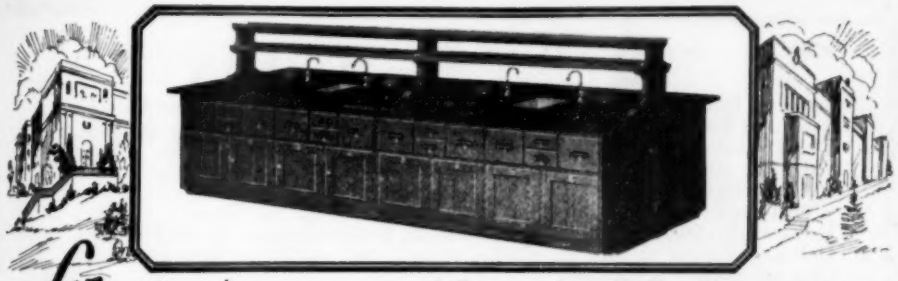
Teaching: Profession and Practice, by A. R. Brubacher, Ph. D., President State College for Teachers, Albany, New York. Cloth. Pages xvii+301. 20x13 cm. 1927. The Century Co., New York. Price $2.00.

Embryology of the Pig, by Bradley M. Patten, Associate Professor of Histology and Embryology, School of Medicine, Western Reserve University, Cleveland, Ohio. Cloth. Pages ix+323. 23x14.5 cm. 1927. P. Blakiston's Son & Company. Price $3.50.

Palladin-Livingston's "Plant Physiology," by Vladimir I. Palladin, Professor in the University of Leningrad, with Additions and Editorial Notes, by Burton Edward Livingston, Ph. D., Professor of Plant Physiology, The Johns Hopkins University. Cloth. Pages xxxv+360. 23x14.5 cm. 1926. P. Blakiston's Son & Company. Price $4.00.

How to Write a Thesis, by Ward G. Reeder, Assistant Professor of School Administration, Ohio State University. Cloth. Pages 136. 16.5x10.5 cm. 1925. Public School Publishing Company, Bloomington, Illinois. Price 90 cents.

Instructional Tests in Algebra, by Raleigh Schorling, Head of Department of Mathematics, The University High School and Associate Pro-



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fessor of Education, University of Michigan, John R. Clark, The Lincoln School of Teachers College, Columbia University, and Selma A. Lindell, The University High School, University of Michigan. Paper. Pages viii+72. 18.5x13.5 cm. 1926. World Book Company, 2126 Prairie Ave., Chicago. Price 28 cents.

Arithmetic for Teacher-Training Classes, by E. H. Taylor, Ph. D., Head of the Department of Mathematics, Eastern Illinois State Teachers College. Cloth. Pages vii+344. 18.5x12 cm. 1926. Henry Holt and Company, New York.

Elements of Physics, by Robert Andrews Millikan, Ph. D., Sc. D. Director of the Norman Bridge Laboratory of Physics, Pasadena, Cal., Henry Gordon Gale, Ph. D., Professor of Physics in the University of Chicago, and Willard R. Pyle, B. S., Head of the Department of Physics, Morris High School, New York City. Cloth. Pages xiii+509. 19.5x 12.5 cm. 1927. Ginn & Company, Chicago.

Student Relationships, an Orientation Course for College Freshmen and High School Seniors, by Walter G. Clippinger, D. D., LL. D., president of Otterbein College, Westerville, Ohio. Cloth. Pages xi+145. 19x12 cm. 1926. Thomas Nelson & Sons. Price $1.50.

General High School Mathematics Book II, by David Eugene Smith, Professor of Mathematics, Teachers College, Columbia University, John Albert Foberg, Director of Mathematics, Department of Public Instruction, Pennsylvania, and William David Reeve, Associate Professor of Mathematics, Teachers College, Columbia University. Cloth. Pages viii+472. 19x12 cm. 1926. Ginn & Company. Price $1.60.

Fourfold Geometry, by David Beveridge Mair. Cloth. Pages viii+ 183. 21.5x13 cm. D. Van Nostrand Company. Price $2.75. 1926.

What Arithmetic Shall We Teach? by Guy Mitchell Wilson, Ph. D., Professor of Education, Boston University. Cloth. Pages vii+148. 17.5x11.5 cm. 1926. Houghton Mifflin Company. Price $1.20.

Principles of Plant Growth, by Wilfred W. Robbins, Associate Professor of Botany in the College of Agriculture of the University of California. Cloth. Pages vii+299. 20x13 cm. 1926. John Wiley & Sons, Inc. Price $2.25.

Conquering the Air, by Archibald Williams, Cloth. Pages xiv+315. 20x14 cm. 1926. Thomas Nelson and Sons, New York. Price $2.00.

Tentative Outline Manual, Elementary Science, Kindergarten and Grades I-VI, by Cleveland Public Schools. Paper. Pages 273. 23x15 cm. 1926-1927. Cleveland Public Schools.

BOOK REVIEWS.

New Complete School Algebra by Herbert E. Hawkes, William A. Luby, and Frank C. Touton. Pages vii+625. 12x18cm. 1926. Boston, Ginn & Co. Price $1.60.

This book combines the material of the "New First Course in Algebra" and the "New Second Course in Algebra." It is designed for courses which are more than one year in length.

Emphasis has been placed on Oral Exercises which appear at the beginning of each new topic. Statistical graphs are treated early in the course. The treatment of graphs and equations is found first in Chapter XIX. Chapters on Logarithms and Trigonometry have been placed earlier in this text than in the older edition. J. M. Kinney.

Junior High School Mathematics, Book III, by George Wentworth, David Eugene Smith, and Joseph Clifton Brown. Revised edition. Pp. iv+338. 14x19.5 cm. 1926. Boston, Ginn. Price $1.20.

The authors point out the fact that there are differences of opinion as to what should constitute a set of desirable topics for the first year in algebra. Accordingly the authors have made this revision flexible enough to satisfy the various tastes.

The first chapter deals with arithmetic of everyday life. This is followed by a number of chapters which present the usual algebraic material. There is a chapter on the trigonometric ratios and another on demonstrative geometry. J. M. Kinney.

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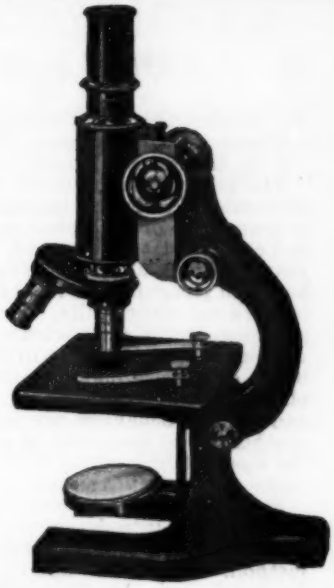

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An Introduction to the Study of Biology, by Alfred C. Kinsey, Indiana University, Bloomington. Pp. xiv+555. 430 illustrations. 1926. J. B. Lippincott Company, 2244 Calumet Ave., Chicago.

The general plan followed in the writing of this high school text is a discussion of biological principles using illustrations drawn from plant life or animal life or both plant and animal life. It thus represents a unified and coherent treatment of life science and not a course made up of a half-year of botany and a half-year of zoology. This method of organization has been recognized as ideal for a course in general biology, but difficult to work out successfully. The author draws upon the different materials according to their importance in connection with the development of the various topics. He states in the preface, "It has not always proved possible to emphasize plants as much as animals, chiefly because we are not plant but animal organisms, and because the phenomena of instinctive and organic behaviors are as peculiar to the animal kingdom as photosynthesis is to the world of green plants; but I have tried to emphasize the resemblances rather than the differences in plant and animal processes and structures."

Sixteen pages are devoted to an introduction to the study of living things. Following the introduction, the topics developed are morphology, physiology, taxonomy, ecology, behavior, genetics, distribution, and history and method. There is an abundance of material sufficient to form the basis for a full year, yet the organization will permit a selection of material for a well-balanced half-year course. The author expresses the notion that it is a mistake to test the importance of knowledge by its known, dollars-and-cents applications; however, he has not avoided practical applications wherever they are known.

The book is written in a style that makes it interesting, not only for the boy or girl who is using it as a text, but also for any one who desires a knowledge of the elementary principles of biology illustrated by interesting facts about well-known plants and animals.

Teaching helps are given in the form of suggestions for developing the scientific method, questions at the end of each chapter, a review chapter giving a list of the most important things under each of the topics that have been developed in the course, and a classified list of reference books.

The illustrations which have been selected with unusual care are of unusual quality. Mechanically, the make-up and binding of the book are in keeping with the high grade of the context. Jerome Isenbarger.

Mental Tests: Their History, Principles and Applications, by Frank N. Freeman, Ph. D., Professor of Educational Psychology, The University of Chicago. Cloth. Pages ix+503. 12.5x18.5 cm. 1926. Houghton Mifflin Company. Price $2.40.

In introducing this book Professor Cubberley says: "No aspect of the development of education during the past decade and a half has awakened more widespread interest, challenged the thinking of more young workers, or been more fruitful in results than the creation of tests and the application of statistical procedures to the interpretation of the results obtained." The testing movement has developed in two fields, the one producing educational tests, the other mental tests. In this book Professor Freeman has given a very complete account of all the important types of mental tests. His attitude toward these tests is well shown in his discussion of reliability. He says: "Mental tests are not absolutely new devices. They are not magical instruments for the discrimination and measurement of mental capacities. Their fundamental characteristics are the same as those of the ordinary examination with which we have been familiar so long."

The first 225 pages trace the historical development of the various types of mental tests, and give the scientific principles applicable to each type. In cases where the principles involved are in dispute all the different viewpoints are presented and the evidence is summarized by the author. Examples of types of tests are given and methods of scoring illustrated. In these chapters the reader is first introduced to the early

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work of Galton, Cattell and others in testing specific characteristics—investigation which grew out of the study of individual differences. Comparison of results developed the correlation method. Scales for testing mental age developed by Binet and modified and revised, first by Binet and Simon, and later by Terman and also by Kuhlmann, and the method of indicating mental development by use of the intelligence quotient are critically examined. Tests for anlyzing mental capacity, the development of point scales, group point scales, and tests of personal traits occupy a chapter each.

Chapter IX to XII give the technique and theory of designing and administering mental tests. Subject matter, selection and organization of the items, scoring and establishing norms, and tabulation of the scores are the topics treated.

A third section of the book, may be considered the practical part, since the purpose here is to show the uses that can be made of mental tests. Here are discussed the study of mental growth; the use of mental tests in promoting education both by the administrator in problems of organization and classification and by the teacher or counselor in diagnosis and guidance; and the application of mental tests in vocational guidance. The relation of intelligence to delinquency is presented in a digest of a series of investigations on this topic. In his interpretation of intelligence tests the author summarizes his view thus: "Intelligence tests have made a marked advance toward the measurement of native capacity, but their scores are still influenced to a considerable degree by the effects of training, and in their interpretation this influence must always be taken into account."

It is the opinion of the reviewer that this book will meet with unanimous approval. The scientific and thought-stimulating method of presentation will establish a precedent and become a model for future textbooks for colleges and universities. While it is written in a manner that adapts it to the layman's use, it is also well organized for instructional purposes. The well-selected bibliographies furnish an abundance of supplementary material. G. W. W.

A Laboratory Guide for General Botany, by C. Stuart Gager, Director of the Brooklyn Botanic Garden, Third Edition. Size 13x19 cm., pages ix + 205, cloth. Published by P. Blakiston's Son & Co., 1926.

The fact that this "guide" is entering its third edition is a good indication of its serviceability. But few changes have been made in this edition of the book,—minor corrections and a few additions and revisions.

It is a very carefully written book for college freshman classes, with full directions for each step. It is the author's belief that beginners in botany of college grade should be taught correct methods of study and the exercises are all written with this in mind. We can heartily commend this "Guide" for those who need such help. It should be particularly helpful to high school teachers of botany who wish to review laboratory studies of plants. W. W.

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